



ESSAYS ON INFLATION DYNAMICS IN SELECTED ASIAN COUNTRIES

by

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ABSTRACT

This thesis analyses inflation dynamics in eight Asian countries. The second chapter analyses inflation persistence and exchange rate pass through (ERPT). The findings on inflation persistence show that for most countries this declines after the Asian financial crisis. The findings for ERPT are more mixed and vary by country. The role of Inflation Targeting Framework (ITF) on inflation persistence and ERPT is also examined. The estimation results suggest it is too early to generalize that ITF exerts a consistently discernible influence on inflation dynamics across this group of Asian ITF countries.

The third and fourth chapters focus on the impact that world oil and world food price shocks have on domestic prices. On average, the pass-through of the world oil price is higher than for world food prices. Another finding is that the domestic food supply capacity of a country succeeds in dampening the effect of world food price shocks.

The fifth chapter employs disaggregated data on prices to examine inflation dynamics in Indonesia. The main finding is that price behaviour exhibits heterogeneity. Disaggregated prices are more flexible in response to sector specific shocks and are more sluggish in response to macroeconomic shocks. In response to deposit rate shocks, the price puzzle becomes weaker after the full implementation of ITF.

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*to my beloved wife, “Nanda” Candra Sari,
who accompanies me wholeheartedly in this journey.*

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Pursuing a Ph.D. is a journey. Writing on this page is like reaching the end of that journey. I try to recall my steps. First of all, this journey is not possible without God's will. The only right I have is, to meet God's will with great efforts. As a result, many experiences, along this journey, have been printed in my mind. At this moment of accomplishment, I would like to thank to several people who make this journey a fascinating and unforgettable experience.

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Chapter 1

Introduction

The study of inflation dynamics is a broad topic; it involves the investigation of inflation persistence, exchange rate pass through and the impact of world commodity price shocks, to name but a few. From the perspective of monetary authorities, the understanding of inflation dynamics is crucial. The main purpose of monetary authorities is to achieve price stability, and thus they have serious concerns regarding inflation dynamics. With sufficient knowledge of the specific inflation dynamics of a country, monetary authorities should have an enhanced ability to predict fluctuations in inflation, and hence should be able to determine a suitable monetary policy to ensure inflation targets.

Knowledge of inflation dynamics for a specific country may vary from conventional beliefs, especially given the irregular characteristics of a country and the time period under observation. Many researchers have found that there have been considerable changes in the inflation dynamics of developed countries. Mishkin (2007; 2008) has revealed that over the past two decades, most developed countries have experienced a lower exchange-rate pass-through; a flattening Phillips curve; reduced sensitivity to oil and commodity price shocks; and lower inflation persistence when compared to previous periods. Mishkin (2007; 2008) argues that this is mainly due to improved performance of their monetary policies. A stable monetary policy, with anchored inflation expectations, whilst being supported by an independent monetary policy framework, can reduce the effect of shocks that threaten the stability of inflation dynamics.

1.1. The Objective

Nearly all of the current literature in the field of investigation discusses inflation dynamics in the context of developed countries. However, few papers have examined this from the perspective of developing countries; namely Asian countries. A decade after the Asian financial crisis occurred, many Asian countries experienced remarkable changes in their economies. Many reforms took place in both the monetary and real sectors, such as adopting new monetary frameworks and market liberalisation and these factors had an effect on the dynamics of macroeconomic variables, for example, inflation.

The objective of this thesis is to contribute to existing knowledge in the subject area by exploring the inflation dynamics of eight Asian countries: four Association of South East Asian Nations (ASEAN) (Indonesia, Malaysia, Philippines, and Thailand) and four Newly Industrialised Economies (NIE) (Hong Kong, Singapore, Korea, and Taiwan).

The following aspects of inflation dynamics are covered: inflation persistence, exchange rate pass through, and the impact of world commodity price shocks. Recently, as more detailed price data has become available, research that explores disaggregated micro data has been growing. However, this literature still focuses on developed countries. To help fill this gap, one chapter of this thesis will contribute to the literature by exploring inflation dynamics using the disaggregated inflation data for a developing country. The character of the contributions can be seen by examining the way each chapter answers the primary research questions posed.

For countries that are building up their monetary policy credibility after the financial crisis, one of the main challenges is how to anchor inflation expectations. If the monetary authority can control expectations, inflation persistence should decrease. This is one positive indicator of the credibility gained by the monetary authority. In addition, a

lower exchange-rate pass-through that is linked to stable monetary circumstances is another positive indicator (Mishkin, 2008). Hence, these two aspects of inflation dynamics are crucial for these countries. Chapter 2 of this thesis examines these two aspects with respect to the following specific research questions:

- **Did inflation persistence change in Asian countries after the Asian financial crisis?**
- **How large is the exchange rate pass through and has it changed after the crisis?**

We use autoregressive (AR) models which are commonly used to measure inflation persistence. In addition, we employ certain AR models, based on the number of lags used to confirm the coefficient of persistence. We split the sample into pre- and post-crisis periods based on the Andrews-Quandt breakpoint test (Andrews, 1993; Andrews and Ploberger, 1994) and on an arbitrary break. The latter treats the break not as a specific date as in the standard statistical method, but as a break-period. Although arbitrary, this break-period may be more reasonable because these countries may have taken some time to recover from the crisis. Furthermore, we also perform rolling window regressions, with a moving sample, to show the evolution of the changes.

For the exchange rate pass through (ERPT), our estimates are based on the theoretical background as shown in Campa and Goldberg (2005). We extend their empirical analysis of the ERPT to import price by also including the ERPT to consumer price. There are more studies that have focused on this in both developed and developing countries, especially after the Asian financial crisis. To provide a different viewpoint, we employ an auto regressive distributed lag (ARDL) estimation approach. We use the bound testing approach of Pesaran, Shin, and Smith (2001) for cointegration testing. According to our knowledge, this approach has not been used to test for ERPT cointegration in the

countries under investigation. Moreover, this approach is suitable for short data samples, as in our case.

As some countries under investigation experienced monetary policy regime changes, **this thesis also determines whether adopting Inflation Targeting Framework (ITF) contributes to the changes.** We follow the same framework as Edwards (2006) who used an ARDL approach to check the role of ITF in four countries: Indonesia, Korea, Philippines, and Thailand.

In general, emerging and developing economies are more vulnerable to increases in world commodity prices than developed countries are. The main reason for this is that these countries have a larger share of world commodities in their consumption and are more energy intensive in production (IMF, 2008). Hence, world commodity prices also play a key role in influencing inflation dynamics in these countries. The third and fourth chapters in this thesis discuss the impact of world commodity price shocks; in particular world oil and world food price shocks, during the 2000s. By placing prices of foodstuffs at the centre of the analysis, this thesis attempts to contribute to the discussion, since up until now, most of the literature has been concerned solely with the oil price shocks.

Chapter 3 focuses on quantifying the impact of world oil price shocks and world food price shocks on domestic inflation in terms of the first and the second pass through. Examining the two steps of pass through for world commodity price shocks is important from a monetary policy perspective. Ideally, the role of the monetary authority is to maintain the medium- to long-term inflation path, with the aim of supporting sustainable economic growth. The monetary authority would probably ignore world commodity price shocks if these were known to be transitory and do not change the medium term inflation path. If the monetary authority tries to keep the inflation rate close to the target rate in the

short term, this can lead to a serious sacrifice of aggregate output. In practical terms, the monetary authority reacts whenever there is a second-round pass through from world commodity price shocks to the domestic inflation rate. However, any attempt to identify whether the shocks are transitory or permanent, or whether they create the second round effect, is a real challenge for the monetary authority. Chapter 3 addresses these pertinent research questions:

- **Which commodity prices have exercised the greatest influence upon domestic inflation?**
- **Do commodity price shocks generate a second pass through effect?**

To quantify this, we use an ARDL approach for both the first and second pass through with different model specifications which follows the research carried out by IMF (2008). As the second pass through is more difficult to identify, we also employ the approach used by Cecchetti and Moessner (2008) to confirm the ARDL results by checking whether there is a reversion between headline inflation and core inflation.

Another approach is measuring the size of persistence of both domestic fuel inflation, and domestic food inflation. The idea behind this is that inflation persistence can also be a source of the second pass through. If the effect of the shocks takes a long time to disappear, inflation expectations can be destabilised. In this case, the shock will generate a second round effect. For this, we adopt the median unbiased estimator of Andrews and Chen (1994).

The analysis in Chapter 3 only quantifies the impact of world oil and world food price shocks. It does not explain or identify how shocks influence domestic prices. In order to complement this, Chapter 4 discusses the story behind the impact of world commodity price shocks and seeks to answer the following research questions:

- **What are the main differences in the monetary policies conducted in the countries under investigation when facing world commodity price shocks?**
- **Given different economic structures, what is the impact of world commodity price shocks, in particular world oil and food price shocks, on the countries' domestic inflation and other macroeconomic variables?**

To answer these two research questions, we develop a Dynamic Stochastic General Equilibrium (DSGE) model of a small open economy under a New Keynesian theoretical framework. The model is based on the model developed by Gali and Monacelli (2005). We extend their model by decomposing the household's aggregate consumption into more detail. We include fuel and food in the consumption bundle. Within the model there are also two firms that produce food and non-food goods. Most of the literature up until now has focused on oil price shocks. This chapter includes world food price shocks in its analysis thus contributing to the discussion on the effect of world price shocks using DSGE models. We use the same model structure to examine the impact of world oil and food price shocks for different countries. Consequently, we reduce the number of countries under investigation. We picked four countries: Indonesia, Korea, Philippines, and Thailand, because they have the same monetary policy framework, which is ITF.

Furthermore, by employing Bayesian estimation, this analysis allows us to compare how the four countries conduct their monetary policy in the framework of inflation targeting. We adopt a policy rule specification resembling the approach taken by Lubik and Schorfheide (2007) where the output and exchange rates are included. This specification allows us to see how far each country's authorities react to output and exchange rate, not just inflation, when deciding their policy rate.

For each country, this chapter provides, impulse responses for some domestic inflation rates and some other main macroeconomic variables to world oil and food price shocks. Different responses, in terms of magnitude and length, provide a comparative study amongst the countries under investigation. To our knowledge, up until now, there have been no studies done that have compared the effect of world commodity price shocks in emerging Asian countries using a DSGE model. Thus, this chapter will contribute to this knowledge.

In common with past studies, three chapters of this thesis use aggregate data. The use of disaggregated data, in particular disaggregated price data, remain unexplored. Econometric studies of aggregated and disaggregated prices could lead to quite different conclusions. For instance, Christiano, Eichenbaum, and Evans (1999) found that prices are sticky at an aggregate level. The aggregate price index does not respond substantially to unanticipated monetary policy shocks for one and half years. On the other hand, some recent studies have revealed different findings. Bils and Klenow (2004), who use micro data, find that prices in the US are much more volatile. Bunn and Ellis (2012), who examine the price behaviour in the UK using micro data, conclude that the frequency of price changes is not fixed over time. Golosov and Lucas (2007) also use micro data from Bils and Klenow (2004) to calibrate their menu cost model and find that prices are more flexible than traditionally portrayed at aggregate level. In another study, Boivin, Giannoni, and Mihov (2009) use disaggregated data on US price indices to explain why the impulse responses of aggregated and disaggregated prices are different. These different explanations lead to the conclusion that when using a more detailed data set, a richer and more thorough analysis can be conducted. We can gain a deeper understanding of inflation dynamics in a certain sector, due to certain shocks, and hence, more accurate policy

recommendations can be derived. This thesis therefore also conducts an analysis of inflation dynamics using disaggregated inflation data.

There is a trade-off between the detail of data and the number of countries that can be accessed. Comparative studies over a number of countries are most likely to use aggregate data because the data are usually only accessible at an aggregate level. On the other hand, we can go into detail on a certain variable, provided that we have detailed data. Chapter 5 focuses on a specific developing country; Indonesia, given the data availability. The following fundamental research questions are addressed:

- **What is the extent of price flexibility in Indonesia?**
- **What is the response of inflation at an aggregate and disaggregated level to monetary policy shocks?**
- **What policy implications can be derived from this analysis?**

We employ a Factor Augmented Vector Auto Regressive (FAVAR) approach following that of Boivin, Giannoni, and Mihov (2009). This technique can analyse prices at both an aggregate and disaggregate level in the same framework simultaneously. The contribution of this chapter should be of great value for policy makers. Empirical findings in this chapter can help to guide policy makers when setting their monetary policy. To the best of our knowledge, this is the first FAVAR analysis using disaggregated Indonesian price data; and it may be the first for any developing country. In terms of the methodology, some data modifications and combinations also contribute new insights to subject field.

Some fundamental aspects of Indonesia's inflation dynamics are revealed. We can see the heterogeneity of persistence and volatility of inflation at a disaggregated level as well as an aggregate level, and determine which shocks are associated with this heterogeneity. We also examine the responses of disaggregated inflation to monetary

policy shocks, in which period the price puzzle occurs, and look at possible explanations for this.

1.2. Structure of Thesis

This thesis is divided into six chapters. This present chapter has discussed background information and motivations for conducting the thesis. The research questions and the contributions are briefly described. Chapters 2 to 5 constitute the core of this thesis. Each of them discusses the research on specific topics of inflation dynamics. Each chapter also provides relevant literature reviews, explanations of the methodology, and data used.

Chapter 2 examines two aspects of inflation dynamics, namely inflation persistence and exchange rate pass through before and after the Asian financial crisis of 1997-1999. It also examines the role of the ITF in influencing the changes of these two aspects of inflation dynamics. To give insights about the information related to this research, chapter 2 also provides a section about inflation and monetary policy in the countries under investigation.

Chapter 3 quantifies the impact of two world commodity price shocks; oil and food prices, in terms of first and second pass through. Chapter 4 discusses the same subject from a different angle using a DSGE model. We explain our DSGE model and also provide a comparative estimation and simulation study among four ITF countries.

Chapter 5 focuses on investigating inflation dynamics using disaggregated inflation data for Indonesia. We explain the FAVAR technique employed and some of the exercises using this technique reveal the inflation dynamics for Indonesia.

Chapter 6 is the final chapter of the thesis and makes overall conclusions about the findings. Future work based on shortcomings and weaknesses of this study is also suggested. The big picture of this thesis is summarised in Figure 1.1.

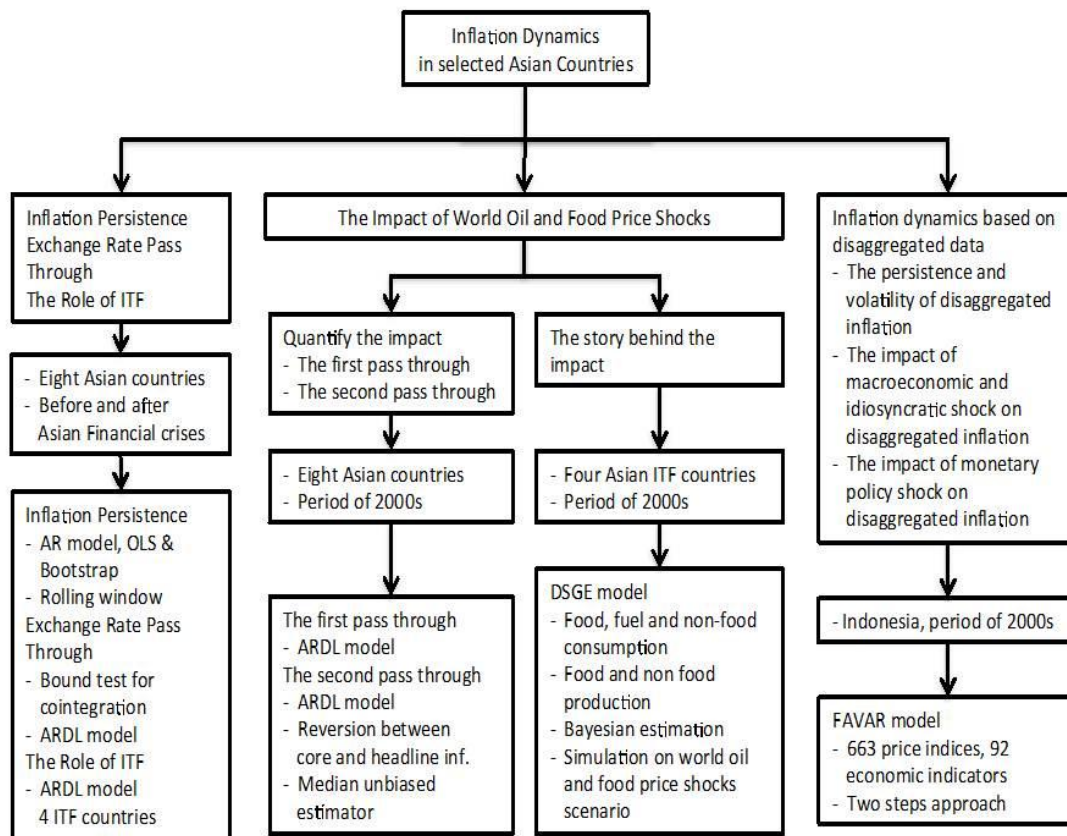


Figure 1.1. Structure of Thesis

Chapter 2

Inflation Persistence And Exchange Rate Pass Through After The Asian Financial Crisis. Is There Any Role Of Inflation Targeting Framework?

2.1. Background and Motivation

Two aspects of inflation dynamics; inflation persistence and exchange rate pass through, are of crucial importance within Asian countries. For countries that have been building up the credibility of their monetary policy after the Asian financial crisis, a positive indicator of this is demonstrated by how successfully the central bank anchors inflation expectations. If the central bank can influence and contain these expectations, inflation persistence should decrease. Economic agents will focus more on the central bank target than on intermittent shocks in the economy. In addition to inflation persistence, a lower exchange rate pass-through is also another positive indicator. Exchange rate depreciation can pose a risk to inflation. The risk depends on to what extent the falling of the currency is passed-through into domestic prices. In a stable monetary condition, this exchange rate pass through is lower (Mishkin, 2008).

Given these facts, exploring inflation persistence and exchange rate pass through is important. This knowledge can provide major support and guidance to the policy makers in the region. Besides this, as most research up until now has focused on developed countries, it provides a comparative study between developed and developing countries. Against this backdrop, the purpose of this research is to answer the following vital questions:

1. Did inflation persistence change in Asian countries after the Asian financial crisis?
2. How large is the exchange rate pass through and has it changed after the crisis?

The Asian crisis brings about several reforms in the economy of the countries under investigation. The relevant reforms with this chapter are the reforms in monetary policies. This includes adopting a more flexible exchange rate system. This allows more effective shock absorption and allows interest rates to be set in response to economic conditions. After the crisis, the demand for the transparency of policies and information availability also increased. In terms of monetary policy, some governments respond to this by adopting a new monetary policy regime, ITF, which provides more transparency and accountability. Mishkin (2007) argues that ITF should produce a better-anchored long-run inflation target, thus it may reduce inflation persistence as well as exchange rate pass through. After evaluating the performance of some aspects of the inflation dynamics in this region, it is important to see how ITF has worked. Hence, the next research question becomes relevant:

3. Does a reform such as adopting an Inflation Targeting Framework contribute to these changes?

The countries under investigation are Hong Kong, Indonesia, South Korea, henceforth Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand. The selection of the countries is based on a variety of considerations. Firstly, they suffered in the Asian financial crisis, albeit to varying degrees. This event led to certain pervasive changes in their macroeconomic variables, including their inflation rates. Secondly, they represent different monetary frameworks. Some of them implement an Inflation Targeting Framework, and some do not. Comparing them can provide insights into the consequences of the implementation of ITF in the region.

The rest of this paper is as follows: Section 2.2 reviews the literature on inflation persistence, exchange rate pass through, henceforth ERPT, and the role of ITF on inflation dynamics. Section 2.3 briefs the reader about inflation experience in the countries under

investigation and their monetary policies. Section 2.4 and 2.5 describe inflation persistence and ERPT respectively. Each provides the data description, the methodology and the strategy employed, along with the results of the estimation. Section 2.6 describes the data, the methodology and the results of the estimation on the role of ITF. Section 2.7 gives conclusions.

2.2. Literature Review

2.2.1. Inflation Persistence

There are several definitions of inflation persistence. Batini and Nelson (2002) give three, namely: (1) “positive serial correlation in inflation”; (2) “lags between systematic monetary policy actions and their (peak) effect on inflation” and (3) “lagged responses of inflation to policy shocks”. Willis (2003) defines IP as the slowness “with which inflation returns to its baseline after a shock”. For Marques (2004) IP is the time “with which inflation converges to equilibrium after a shock”. This chapter follows the definition that is commonly used in the literature, that inflation persistence reflects the speed and pattern of inflation adjustment given a shock (for example, Angeloni, et al., 2004; Altissimo, et al., 2006; Mishkin, 2007). The longer the inflation path takes to return to its initial level, the higher its persistence.

There are two reasons for investigating this phenomenon. First, when the degree of inflation persistence is high, the changes needed to stabilise inflation are substantial. Much output must be sacrificed for a while, in order to reduce inflation, especially if policy makers wish to reduce inflation quickly. The sacrifice ratio is high. Second, the existence of a high degree of inflation persistence undermines any effort to anchor inflation expectations, which is fundamental in monetary policy. High inflation persistence renders

the central bank weak, or forces it to take the risk of conducting sharp monetary tightening. However, by knowing the degree of inflation persistence, policy makers can contrast the likely consequences of different courses of action and will be in a better position to select the most appropriate one.

According to Altissimo et al. (2006), there are four sources of inflation persistence. These are extrinsic persistence, intrinsic persistence, expectation based persistence and monetary policy. The first three can be described from the perspective of the New Keynesian Phillips Curve, henceforth NKPC¹. In one version of the NKPC equation (for example, Gali and Gertler, 1999), inflation is a function of its own lag, expected inflation and output gap.

$$\pi_t = \gamma\pi_{t-1} + (1 - \gamma)E_t\pi_{t+1} + \kappa y_t + u_t \quad (2.1)$$

Extrinsic persistence relates the source of inflation persistence to how the firms set their prices. In the NKPC equation it is reflected by the coefficient (κ) on the real marginal cost, or can be approximated by the output gap. This coefficient depends on the proportion of firms that set their price based on the previous level. The lower the proportion, the higher the coefficient. If this coefficient increases, more firms set their prices based on current economic conditions. In this case, inflation is less persistent. On the other hand, a low coefficient suggests that many firms set their prices in a backward looking fashion. The source of persistence is intrinsic, and is reflected in the structure of the time lag for inflation or coefficient (γ) of equation (2.1). By contrast, when most firms set their prices according to their forecast of future economic conditions, the coefficient of $(1-\gamma)$ is high. This is expectation-based persistence. It also depends on how firms form their

¹ NKPC refers to the Phillips Curve that is derived from microfoundation under the assumption of a monopolistic goods market and price rigidity setting, such as Calvo price setting. NKPC depends on Dixit-Stiglitz monopolistic competition, which allows firms to optimize their price setting.

expectations; if this is based on rational expectation, the inflation persistence is lower. On the other hand, if it is based on learning, the persistence is higher. Monetary policy also plays a major role in inflation persistence. Its role is reflected in smoothing parameters (ρ) in the reaction function as follows:

$$r_t = \rho r_{t-1} + (1 - \rho)(\alpha_\pi E_t \pi_{t+1} + \alpha_y y_{t+1}) \quad (2.2)$$

If the coefficient of smoothing (ρ) is high, the reaction of the policy rate will be more gradual. As Altissimo et al. (2006) show, if the response of the interest rate to inflation is high, the rate will be higher for a prolonged time. This causes inflation to revert to its initial level more rapidly. In other words, inflation will be less persistent.

Many economic models have tried to explain the phenomenon of inflation persistence using various approaches. Cecchetti and Debelle (2006) classify the models into time dependent models and state dependent models. Time dependent models include the backward looking model developed by Galí and Gertler (1999). Meanwhile, Rotemberg's (1982) model of quadratic cost of price adjustment, sticky information model (Mankiw and Reis, 2002) and menu cost models (e.g. Golosov and Lucas, 2007) are classified as state dependent models. In terms of expectation formation, there is a new approach that is classified into bounded rationality models. This includes learning models (Evans and Honkapohja, 2001, Milani, 2007) and rational inattention models (Mankiw and Reis, 2002).

Mishkin (2007) argues that most developed countries experience inflation dynamic changes, including their inflation persistence. Some researchers support this argument; for example, Levin and Piger (2004) find large declines in inflation persistence for the major European countries as well as in Japan, Canada, Australia and New Zealand, which have occurred since the 1980s. They also emphasise that measurement is conditional on a break

in the intercept. If a break is allowed, the inflation rate is much less persistent than previously thought if a break is allowed.

Using both aggregate and disaggregate inflation data, Cecchetti and Debelle (2006) observe inflation persistence in developed countries. They employed a univariate approach AR(12) model and find that the means of the inflation process has declined over the past two decades. However, by allowing for a change of the means, they demonstrate that inflation persistence does not decline significantly. They conclude that monetary policy and recession do in fact play a meaningful part in the change of the mean but not of the persistence. By contrast, O'Reilly and Whelan (2004), and Gadzinski and Orlandi (2004) provide little evidence of such a change in the Euro Area.

Stock and Watson (2007) show the evolution of inflation persistence in the US, from the standpoint of inflation forecasting performance. They compare the forecast performance of the univariate approach, such as the AR model and the multivariate approach like that of the backward looking Phillips Curve model. Their sample is 1970Q1-1983Q4 and 1984Q1-2004Q4. They find that the forecast performance, which is inferred from Mean Square Forecast Error, of the univariate approach declines. At the same time, the forecast performance of the multivariate approach worsens. Based on this, they scrutinise the change in the inflation process using a univariate approach, in particular an unobserved component model with stochastic volatility. This model decomposes inflation into a permanent stochastic trend component and a serially uncorrelated transitory component. They find that the importance of permanent components declines over time. The period of 1970 to 1983 is characterised as having high volatility, 1984 to 1990 as a period of moderate volatility, and 1990 to 2004 as a period of low volatility. Meanwhile,

the transitory component is relatively stable. This finding implies that the AR model needs longer lags and greater coefficients in order to approximate the inflation process better.

Cogley et al. (2010) also use predictability to measure inflation persistence in the US. Instead of using raw inflation, they use the inflation gap, which is the gap between inflation and trend inflation. They use this to determine the speed and effectiveness of monetary policy to bring inflation to its target. They measure persistence by the fraction of total variation in the forecast period due to past shocks, relative to what will occur in the future. This fraction converges to zero as the period of forecast lengthens. The speed of convergence reflects persistence; if the effect of the shocks decays faster, the persistence is lower. They use a VAR model with drifting coefficients and stochastic volatility in the parameters of innovations to generate this fraction through its forecast error. They find that inflation gap persistence declined after the 1980s. Based on this statistical result, they build a New Keynesian model to examine the factors that led to these changes. They estimate the model based on two sample periods: 1960Q1–1979Q3 and 1982Q4–2006Q4. They find that a better anchored long run inflation target during and after Volcker disinflation contributes to the decline in the persistent component of inflation gap dynamics. In addition to this, the mark up shock was also less volatile and less persistent after the mid 1980s.

While there are many papers discuss inflation persistence in developed countries, only a few investigate it in the context of developing countries, especially in Asia. For example, Alamsyah (2008) investigates inflation persistence in Indonesia and finds it is relatively high compared to other countries in the region, even though it is found to be declining after the crisis. The author provides simulations using a DSGE model to determine how monetary policy should respond to such a situation. Gerlach and Tilmann

(2010) examine inflation persistence in some Asian countries in the context of ITF. They compare the degree of inflation persistence in Asian countries with and without ITF, in some non-Asian countries, and also in some emerging and developed countries that adopt ITF. Using an autoregressive specification, their findings suggest that inflation persistence in countries that adopt ITF decline as it appears to developed countries. On the other hand, it does not decline in countries that adopt other monetary policy regimes. Based on this, they conclude that ITF influences these phenomena, even though they do not provide a formal estimation to prove this.

2.2.2. Exchange Rate Pass Through (ERPT)

In addition to the inflation persistence, ERPT is also an important aspect of inflation dynamics. The concept of ERPT first emerges when the hypotheses on Purchasing Power of Parity, hereafter PPP, is challenged on empirical (or theoretical) grounds, such as cross country differences in weight for price indices, indirect tax structure, transport costs and trade restriction. Much research across various countries and across a variety of goods does not support the assumption of PPP. Accordingly, many researchers begin to develop models that relax this assumption. This has implications for the concept of pass through. The terminology of ERPT relates to the transmission of exchange rate changes into the prices of importable or exportable goods as well as aggregate domestic price levels. The prices are given in terms of the currency of destination countries. Algebraically ERPT is equal to the formulation of the elasticity.

$$ERPT = \frac{dP}{d\varepsilon} \frac{\varepsilon}{P} \quad (2.3)$$

Where P is the price level, which could be an import price, or a tradable price, or an overall price level. ε is the exchange rate, defined as the nominal price of foreign

exchange. There are two stages of ERPT: first and second stage pass through. The former examines the effect of the exchange rate on export/import prices. The second stage pass through examines its effect on domestic price levels. The latter is usually lower as non-tradable goods are included in domestic price indices. Both stages may display distributed lags.

As ERPT reflects the transmission of the exchange rate to domestic prices, there are two levels of this transmission: complete and incomplete pass through. ERPT is complete if there is a one to one relationship between the change of the exchange rate and that of the relevant domestic price. It is incomplete, or partial, if domestic prices change less than the change of exchange rate. Theoretically, if PPP holds, ERPT should equate to unity. However, empirically the degree of ERPT tends to be less than unity or incomplete for various reasons as shown by Goldberg and Knetter (1997).

Usually, consumer prices for traded goods have already incorporated domestic prices such as transport or distribution costs. Sometimes this component represents a greater proportion than the price of the product itself. This component is relatively insensitive to the fluctuation of exchange rates so that the ERPT is incomplete. Some authors point this out; for example, Burstein, Neves and Rebelo (2003), and Campa and Miguez (2006). Another explanation for incomplete ERPT is cross-border production, or production sharing (Bodnar, Dumas and Marston, 2002; Hegji, 2003). It is commonly observed nowadays that several elements of a product are produced in several different countries. Production at different stages can also be conducted at different countries. One reason is some countries incur lower production costs relative to other countries. By doing this, the price of the final product embodies costs in several different currencies that do not move simultaneously. If the currency of a country appreciates, it may be counterbalanced

by another currency that depreciates. As a result, the ERPT is less than unity; it lowers ERPT to a certain degree.

There are some factors that determine the degree of ERPT. One of these is the nature of goods or industries. If the nature of the industries is monopolistic, the ERPT may be incomplete. Exporters that do not face such intense competition are less responsive to any fluctuations in the exchange rate. For instance, the appreciation of a domestic currency relative to the currency of an exporter's country is not followed by a reduced export price since the exporter wants to keep its export price constant for various reasons. It may even increase the export price. Conversely, in order to maintain their market share in a given country, exporters absorb the appreciation of their currency relative to that of the currency destination by reducing their mark up price. The behaviour of exporters, as explained above, is commonly said to be pricing to market (Krugman, 1987). This terminology refers to the ability of firms that have market power to sell the same product at different prices to different markets. Empirically, Knetter (1993) finds different degrees of ERPT across industries in the US. Imported goods, such as cars and alcoholic beverages, show a higher pricing to market and a lower ERPT. Campa and Goldberg (2005) find evidence of partial ERPT, especially in the manufacturing goods taking place in 23 OECD countries.

Froot and Klemperer (1989) explain that when the USD is expected to appreciate temporarily, exporters immediately raise their price in the USD. The consideration is that the USD will depreciate and erode their profits in the future. There is a shift of future profit to present. On the other hand, if they expect a permanent appreciation, it does not create a shift of profit from the future to today. The exporting cost will fall and exporters tend to reduce their price unambiguously. Hence, ERPT is almost complete. Meurers (2003) also documents that ERPT is nearly complete given a continuous exchange rate shock in the

US, Germany, France, Italy and Japan. In conclusion, the duration of exchange rate changes influences the degree of ERPT. If the exchange rate change is continuous, ERPT tends to be almost complete.

The direction of exchange rate change is also matters. The effect of appreciation and depreciation is asymmetric. When the USD appreciated in the mid 1980s, import prices became significantly lower. In contrast, when the USD depreciated, import prices rose only slightly. When the USD appreciated, or an exporter's currency depreciated, exporters wanted to expand their export to gain market shares, given that their prices had become cheaper. For these reasons, they reduced their export prices, which led to a higher degree of ERPT. Pollard and Coughlin (2004) find this asymmetric effect on US import prices in 30 industries.

Krugman (1987) proposes that the size of an exchange rate change also determines ERPT. If the change is small, firms generally absorb it and keep their prices unchanged. He argues that firms are willing to absorb any small changes in the exchange rate because they do not want to lose their reputation as they have already announced their prices. In addition, extreme appreciation has a significant impact on ERPT. Based on the extreme appreciation of the USD in the 1980s, Baldwin (1988), Baldwin and Krugman (1989), and Dixit (1989) have developed a model that explains a phenomenon called a hysteresis effect. A sufficiently large exchange rate change, even if it is temporary, can permanently alter the degree of ERPT and the level of imports. When the USD appreciated significantly in the 1980s, foreign firms entered the market. Given the entry cost was sunk, they remained in the US market when the USD returned to its normal level. This created a structural change in the market and changed ERPT.

Related to the currency chosen by an exporter, Gopinath et al. (2010, AER) examine the effect of currency choice on export products to the US, whether in the USD or not, on exchange rate pass through. The authors use unpublished monthly micro data on import prices from the Bureau of Labor Statistics for the period of 1994-2005. The imported goods included in the data are from both developed and developing countries. Using the standard pass-through specification, they find: (i) the difference of ERPT between the USD price and the non USD price of imported goods is quite striking from the short run up to 24 lags. Using contemporaneous and one lag regression, the ERPT of the USD is 0.03, while it is 0.96 in non-USD. (ii) The ERPT increases in the USD priced goods and slightly decreases in non-USD priced goods. (iii) The higher the fraction of producer currency pricing (PCP) or pricing in non-USD, the higher the aggregate ERPT.

In another paper, Gopinath et al. (2010, QJE) use the same data and find that in US imported goods, the high frequency price adjustment goods have a higher long-run pass through than that of low frequency price adjusted goods. Theoretically, they show that this relationship occurs because variable mark ups that reduce the long run pass through, also influence the firm's willingness to adjust their prices.

Most of the factors explained above are from a microeconomic perspective. Taylor (2000) provides an explanation from a macroeconomic perspective. He argues that a country's macroeconomic fundamental policy also plays a significant role. ERPT is endogenously determined by a nation's monetary policy and stability. A more stable monetary condition leads to a low ERPT. He mentions that the establishment of a stronger anchor for inflation expectation has led to lower pass through found in recent data. Gagnon and Ihrig (2004) confirm this argument for industrial countries. In line with this, Devereux and Engel (2001) argue that when an exporter sets its price according to local currency

pricing, its ERPT to import price is low in a country with stable monetary conditions. Campa and Goldberg (2005) also find evidence of the role of macroeconomic variables to the ERPT of import prices in 23 OECD countries. These variables are: inflation, money growth, and exchange rate volatility. However, they emphasise that the composition of imports from raw material and energy towards manufacturing goods is more important when explaining the change of the ERPT in those countries. Frankel et al. (2005) also find that a lower income economy, a smaller, and a more open economy tend to experience greater ERPT.

With regards the development of ERPT, Mishkin (2008) argues that it has been very low in developed countries over the past two decades and there is much literature to support this argument. For example, McCarthy (2000) records a decline in ERPT from the period of 1976-1982 to the period of 1983-1998. Gagnon and Ihrig (2004) also present a study of ERPT in industrial countries. They split the sample according to a country specific break point in the early 1980s where they switched to a more stable monetary policy regime. By doing so, they find a significant decline in ERPT. Another research that focuses on developed countries is that of Ihrig, Marazzi and Rothenberg (2006). They study the ERPT for both import and consumer prices in G7 countries: the US, the UK, Japan, Italy, Germany, France, and Canada. They estimate exchange-rate pass-through with quarterly data from 1975Q1 to 2004Q4 using import prices and consumer prices as dependent variables. For the first pass through, they find ERPT in all countries has declined. A ten percent depreciation increased average import prices by nearly seven percent in the late 1970s and 1980s, and subsequently by four percent over the last fifteen years. Nearly every country experiences a decline in the second pass through from two percent in the late 1970s and 1980s, to an almost neutral level in the last fifteen years.

Marazzi and Sheets (2007) also document that the first pass through in the US declined from around 0.5 in the 1970s and 1980s to 0.2 in the decade from 1995. The reduced import share of material intensive goods is one reason for this. Another reason relates to rising Chinese products in the US market share. This increased competition amongst foreign exporters that affected their price setting. The third reason is pricing to market, or local currency pricing, where foreign exporters set their prices in terms of the USD.

In the past, there have been relatively few papers written that have discussed the development of ERPT in developing countries, particularly in Asia. In his literature survey, Menon (1995) emphasises this and suggests that the researcher should pay more attention to small open economies. And in the aftermath of the Asian crisis, this becomes a more interesting topic. One relatively recent study is that done by Ito and Sato (2008), who examine ERPT on domestic prices in the East Asian economies that were hit by the Asian crisis. These countries are Indonesia, Malaysia, Korea, Philippines and Thailand. They employ VAR models on the basis that a single equation model disregards the possibility of domestic inflation affecting the exchange rate. They use monthly data from January 1994 to December 2006. Their main findings are as follows: (i) the degree of the exchange rate pass-through to import prices was quite high in the crisis-hit economies, (ii) the pass through to Consumer Price Index (CPI) was generally low, except for in Indonesia, and (iii) in the case of Indonesia, they found that an accommodative monetary policy, together with the high degree of ERPT on CPI was an important factor in the inflation-depreciation spiral in the wake of the currency crisis.

Another ERPT research paper focusing on Asia is that written by Mihaljek and Klau (2001). They examine the effect of the exchange rate and import price changes,

which are measured in foreign currency, into domestic inflation in thirteen emerging market economies. Some of them are Asian countries, namely: Korea, Malaysia, Philippines and Thailand. They divide the sample in the 1990 based on the Chow test and use a single equation model to estimate each sample. One of the main results of the study is that the effect of exchange rate changes into inflation is more significant than that of import price changes, however, both have declined since the mid-1990s. A more stable macroeconomic condition and structural reforms are the potential explanations.

2.2.3. The Role of Inflation Targeting Framework on Inflation Dynamics

Does any change in inflation dynamics such as inflation persistence and ERPT accompany or follow a change in the monetary policy regime? In particular, does ITF play a significant role in this case? This is still an unresolved issue in developed countries. There is a large body of literature that discusses this. One of the arguments is that a better inflation environment lowered ERPT and inflation persistence in the 1990s, e.g. Taylor (2000), and Mishkin (2007, 2008). A better inflation environment is due to improved monetary policy performance, and one of the causes of this is the implementation of ITF.

There are various reasons why a country may adopt ITF. Mishkin and Hebbel (2001) note that credibility is the soul of ITF and adopting it should bring about greater credibility. This understanding led to some countries experiencing high inflation, to adopt ITF such as Chile, Israel, and Mexico. On the other hand, most industrial countries adopt it when they experience a low level of inflation. The authors also state that most of these countries do not follow the five pillars of ITF when they adopt it for the first time². Most

² The pillars are: (1) absence of other nominal anchors, (2) an institutional commitment to price stability, (3) no fiscal dominance, (4) independent policy instruments, (5) transparency and accountability. Pillars 2 to 5 are also requirements in any regime while no.1 is needed if a country conducts a fully fledged IT. At its first adoption, Israel still targeted the exchange rate. The Bank of England initially didn't have instrument

inflation targeters are also not “inflation nutters”³ because they typically react symmetrically to positive and negative shocks, pursue disinflation gradually and react to temporary output shocks.

Mishkin and Hebbel (2001) analyse whether there is a structural difference between ITF countries and non-ITF countries. The period under study is the 1990s and consists of eighteen ITF countries and nine non-ITF countries. They use a multivariate probit model to specify the probability of having an ITF regime as a function of certain variables. While some variables are exogenous to the choice of ITF, the reverse is also likely, or the adoption of ITF could also result in an improved macroeconomic performance. One of the results confirms that ITF is positively and significantly related to the level of inflation. It implies that ITF has been adopted by countries that have high inflation. It is commonly known that a switch to a new monetary policy regime (e.g. ITF) is very likely to ensue, following a failure of an earlier regime. In this case these authors note that ITF has successfully reduced the level of inflation, but not to a level that is below that of industrial countries. Furthermore, they argue that the central bank’s independence, communication, transparency and accountability are mutually reinforced under an ITF regime. In line with that, Corbo et al. (2000) report that inflation persistence and inflation forecast errors have declined consistently in ITF countries during the 1990s. One of their findings is in contrast with Bernanke et al. (1999), who find there is no change in the sacrifice ratio related to the inflation persistence after the adoption of ITF. Corbo et al. (2000), who use a larger sample, conclude that it does reduce the sacrifice ratio.

In terms of ERPT, Edwards (2006) checks the effect of ITF in two advances and five emerging countries, using quarterly data for the period 1985-2005. His estimation

independence, and Korea still targeted its exchange rate in its first two years of adoption. Brazil, however, is the only one who adopted a fully fledged IT from the start.

³ This terminology is coined by King (1997).

results suggest that during pre-ITF, the coefficients of pass through are positive and have high variation. The countries that have experienced high inflation (e.g. Brazil) have higher ERPT in both the producer price index (PPI) and the consumer price index (CPI) when compared to other countries (e.g. Korea). Point estimates of PPI are higher than those for CPI. Edwards (2006) reports that the countries experienced declining pass through after adopting ITF. Following the same method, Siregar and Go (2008), who used monthly data from January 1990 to June 2007, also suggest that pass through has declined in both Thailand and Indonesia.

In a thought-provoking paper, Ball and Sheridan (2003), try to determine whether ITF improves economic performance; in particular the evolution of inflation, output, and interest rates. They study twenty OECD countries. Countries that experienced relatively high inflation are excluded, such as Greece, Iceland and Turkey. They define the time a country adopts ITF as different from that in Bernanke et al. (1999), who set the starting date according to the publishing date. According to them, the countries adopt ITF when they have already set their target of inflation, and not when they publish that they adopt ITF formally⁴. They estimate cross section differences in differences approaches using quarterly samples from 1960Q1 to 2001Q4 as follows:

$$X_{post} - X_{pre} = a_0 + a_1D + X_{pre} + e \quad (2.4)$$

Where X denotes a country's indicators such as average output, inflation and interest rate, before and after ITF. D is dummy of ITF and not a time dummy. Coefficient a_1 is expected

⁴ To some countries, the goal of monetary policy is price stability and sometimes they have set the inflation target but they formally have not declared they are an ITF country. For example, Indonesia had a new Central bank act in 1999, which declared the objective of monetary policy is Rupiah stability that implied price and exchange rate stability. This provides the foundation of ITF and practically Indonesia more or less adopted ITF at that point. However, Indonesia formally implemented ITF in July 2005.

to be negative. It implies that the indicator is less if ITF is implemented. X_{pre} in the right hand side is to control different initial performance.

The results suggest that in terms of inflation mean, when a control variable is included, the significance of coefficient a_I is weak. In terms of inflation variability, there is no evidence whatsoever that ITF reduces it. For inflation persistence, they estimate an AR(4) model and find that both ITF and non ITF countries experience the decline. For output growth and its variability, they also conclude that ITF does not matter. Interest rate volatility is lower for non-ITF countries; the decrease appears larger, but does not when the mean is controlled. Based on the results, the authors suggest that both ITF and non-ITF countries may be pursuing the same goals.

However, when we look at some of the research that have investigated emerging market countries, we find contrasting results. Goncalves and Salles (2008) use the same method as Ball and Sheridan (2003) and use 36 emerging market countries. They confirm that adopting ITF does in fact lower the inflation rate and its volatility. Brito and Bystedt (2010) also support this view. Using panel data, they estimate four dependent variables; namely inflation and its standard deviation, and output and its standard deviation. In short, their finding is that adopting ITF lowers the inflation in emerging market countries, but at the cost of output growth. However, there is no firm conclusion that ITF, which should lower output and inflation volatility, promotes long run output through better predictability.

This unresolved issue is also revealed by Filardo and Genberg (2011). The authors evaluate the performance of ITF by comparing the behaviour of inflation in 1985Q1-1997Q2 and 2001Q1-2008Q4 in Asia Pacific countries. Initially, they compare some governance indicators of ITF. They monitor an index of Central Bank Independence and

Governance (CBGI). It shows improved performance from 1996 to 2005. The central bank transparency is also considered. Most of the countries, whether they conduct ITF or not, show better performance in this respect.

They examine inflation behaviour in terms of the mean, the volatility, the persistence and the permanent and stochastic component. For the persistence, they employ AR(1), and for the latest they employ IMA(1,1,1). Their conclusion is that inflation behaviour improved on average, but it is unclear whether adopting ITF contributes to this. The authors also provide evaluation from the perspective of ex ante inflation. They evaluate surveys of the next year forecast of private sectors in each country and look at their cross sectional distribution. If over time, the distribution shifts to the left, it indicates that the mean distribution of inflation becomes lower. Moreover, if the shape of distribution is less dispersed, it implies that the forecast of private sectors is well anchored. The dates of the survey are 1996, 2001, 2006 and 2009. Overall, the cross sectional distribution shows better performance in ITF countries compared to that in non-ITF countries.

They also perform panel data analysis using Kullback-Liebler⁵ statistics, derived from the cross sectional distribution, to evaluate whether ITF improves this statistic. Overall, the results confirm that there is greater emphasis on targeting inflation, albeit not explicit inflation targeting. Central bank inflation fighting credibility appears to have risen. However, the panel evidence suggests that contributions to this are not so well determined. Furthermore, they check whether inflation expectation was well anchored during the commodity price boom in 2008. Again they cannot clearly determine whether inflation expectations are better anchored in ITF countries during that time.

⁵ The Kullback-Liebler (KL) statistic measures the difference between two probability distributions. In this case a higher KL statistic indicates a reduction in the dispersion of distribution private sector views about the likely inflation outcomes. It implies a sharper shape of the forecast distribution.

Based on the literature review above, we shall extend the finding of previous research with more updated data and a different methodology. To measure inflation persistence we shall employ a univariate approach, which is a commonly employed methodology, but we also compare some univariate approaches, and thus can confirm the changes with greater confidence. To measure the dynamics of ERPT before and after the crisis, we shall use an ARDL cointegration approach, which to the best of our knowledge has never been employed in previous research for the countries under investigation. To answer the third question: whether ITF plays a significant role in the changes, we estimate each ITF country using a standard ARDL approach. Before continuing to the methodology and the estimations results, we will briefly look at the characteristics of inflation and monetary policy in the countries under investigation.

2.3. Inflation and Monetary Policy in the Countries Under Investigation

2.3.1. Characteristics of Inflation

We start with a comparison of the mean inflation rate that is calculated using the average of inflation for the whole sample. We can classify the countries under investigation into three subgroups. First, the countries that experience inflation below three percent per year: Singapore, Taiwan and Malaysia. Only the oil price shock in 2008 made inflation rate in these countries dramatically increase. Second, countries such as Thailand, Hong Kong and Korea, on average, experience inflation around four percent. Besides the oil price shock in 2008, inflation in these countries increased sharply during the Asian crisis. Third, Philippines and Indonesia have the highest average inflation. Over time the inflation in these countries almost reaches two digits. In addition, Indonesia's inflation

reached more than eighty percent during the crisis. This means that inflation on average the highest among the countries.

Table 2.1. Inflation Means 1985Q1-2010Q1

Country	Inflation Mean (QtQ)	Inflation Mean (YoY)
Singapore	0.379	1.490
Taiwan	0.448	1.810
Malaysia	0.655	2.610
Thailand	0.900	3.610
Hong Kong	0.945	3.900
Korea	1.100	4.370
Philippines	1.696	7.630
Indonesia	2.494	10.600

To see the characteristics of inflation in each country we divide the sample into two based on the period of crisis; before and after the Asian financial crisis. In this section we divide the sample by the crisis period so that there are two subsamples 1985Q1-1997Q2 and 2000Q1-2010Q1. In the next section we also divide the sample by a structural break test. Most of the countries show lower inflation after the crisis.

In terms of the mean, all the countries experience lower inflation after the crisis except for Indonesia. Before the crisis, Indonesia's government administered many goods, particularly fuel prices. After the crisis, during the oil price shock 2002 and 2005, the government reduced the subsidy for budgeting reasons. This policy increased inflation drastically. It also raised the volatility of inflation, as shown on its higher standard deviation relative to others after the crisis.

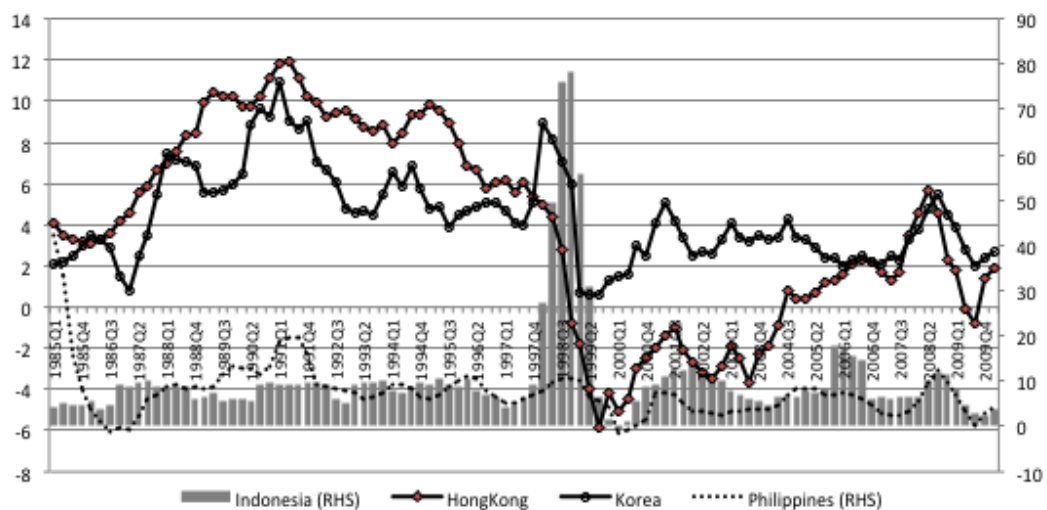


Figure 2.1. Inflation (YoY) of Hong Kong, Indonesia, Korea, and Philippines

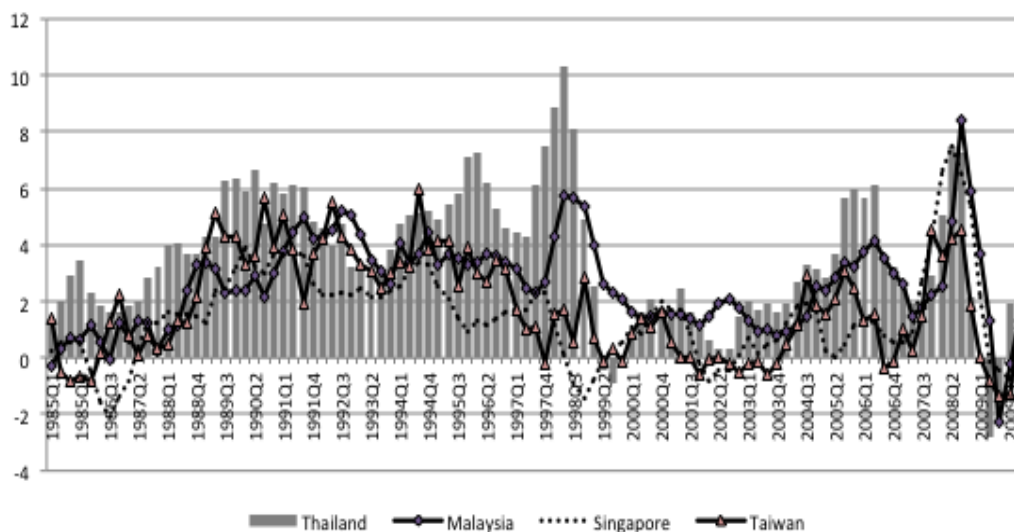


Figure 2.2. Inflation (YoY) of Malaysia, Singapore, Taiwan, and Thailand

The declines of inflation in Malaysia and Singapore are the smallest. This is because the countries experienced relatively high inflation during the 2008 oil price shock compared to their average of inflation. On the other hand, inflation in Hong Kong and Philippines declined sharply. In terms of the volatility, which is reflected by the standard deviation, most countries experience higher volatility after the crisis except for Korea, Philippines and Taiwan.

Table 2.2. Mean and Std. Deviation of Inflation (YoY) Pre and Post Crisis

Country	Pre crisis ¹		Post crisis ²		Difference ³	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Hong Kong	7.827	2.533	-0.103	2.6	7.93	-0.067
Indonesia	7.766	2	8.363	4.159	-0.597	-2.159
Korea	5.436	2.233	3.108	0.93	2.328	1.303
Malaysia	2.728	1.463	2.194	1.719	0.534	-0.256
Philippines	9.877	7.383	4.829	2.983	5.048	4.4
Singapore	1.76	1.4	1.424	1.964	0.336	-0.564
Taiwan	2.677	1.784	0.984	1.515	1.693	0.269
Thailand	4.307	1.56	2.489	2.17	1.818	-0.61

1. The period is 1985Q1-1997Q2; 2. The period is 2000Q1-2010Q1; 3. Positive means declining

2.3.2. Monetary Policy⁶

Before the crisis, most of the countries managed their exchange rate and/or targeted money growth. Usually, their central banks have multiple objectives, not only stabilising the price level, but also promoting economic growth or stabilising aggregate output. There is a similarity in some countries. They abandon monetary targeting because the relationship between money indicators and prices and nominal income became less stable due to financial integration and innovation.

The Bank of Korea (BOK) used a range of money indicators as the intermediate target of monetary policy before the Asian crisis. In 1976, BOK set M1 as the target. Three years later, it changed to M2 since the demand for M1 became less stable. After the crisis, with IMF's advice, BOK adopted a broad measure of money M3. Based on the revised act that took effect on April 1998, Korea formally adopted ITF. Korea implemented it at the start of 1999. However, BOK kept the two pillars but still set the target rate of M3 growth

⁶ This section is mostly taken from proceeding of BIS/HKMR Conference on Monetary Policy in Asia: approaches and implementation that is held in Hong Kong on 21-22 November 2005.

to prevent confusion in financial markets. For two years beginning in 2001, M3 targets were not set any longer but only monitored. This implied that BOK had adopted ITF fully.

The Bank of Thailand (BOT) and Bangko Sentral Pilipinas (BSP) also adopted ITF. Monetary policy in Thailand has two goals, namely low inflation and a stable exchange rate, based on The Bank of Thailand Act 1942. The Bank of Thailand opts to stabilise its effective exchange rate, but inflation is its overriding target. It set the short-term interest rate on the basis of official inflation target, since it adopted ITF formally in May 2000. Its inflation target is core inflation. In contrast, under the Act of 1993, monetary policy in Philippines mentions price stability as the only objective of the BSP's monetary policy. It empowers BSP as the sole formulator and executor of monetary policy. The act also imposes the amount and maturity of credit to the national government to minimise fiscal dominance. In January 2000, BSP formally adopted ITF. It announced the target two years later in January 2002. Its target for the CPI is set by the national government in coordination with BSP and other bodies.

Before adopting ITF, the Bank Indonesia's monetary policy was eclectic, and attempted to control interest rates, money, and the exchange rate. At the time, the objective was vaguely formulated. The main anchor was the exchange rate. Keeping the exchange rate in the narrow range in the open capital account made the monetary policy face a very large challenge. This led to the flexible exchange rate during the crisis given the speculative attack. According to the 1999 Bank Indonesia Act, after the crisis, Rupiah stability became the objective although it was somewhat ambiguous. It means the stability from the perspective of other currency or good and services bought by the Rupiah. However, these two were closely related, since the stability of exchange rate could contribute to the stability of prices. The new law granted Bank Indonesia the independence

that supported the conduct of ITF. This framework was formally and fully implemented from July 2005.

In contrast to the above countries, Malaysia, Singapore, Hong Kong and Taiwan do not adopt ITF. Monetary policy in Malaysia has two goals; namely low inflation and a stable exchange rate. Moreover, the contribution of the goal to growth and development is often stressed. From 1998 to 2005, Malaysia pursued a fixed bilateral exchange rate against the USD. However, on 21st July 2005 it committed to the effective exchange rate. It set the short-term interest rate on the basis of an implicit inflation target, but this is not an official target.

Table 2.3. Central Banks Objectives

Central Bank	Policy Objective	ITF (year and target)
Hong Kong Monetary Authority	Exchange rate stability	No
Bank Indonesia	Rupiah stability	Yes, 2005, CPI
The Bank of Korea	Price stability	Yes, 1999, Core inflation
Bank Negara Malaysia	Price and exchange rate stability	No
Bangko Sentral ng Pilipinas	Price stability	Yes, 2002, CPI
Monetary Authority of Singapore	Price stability	No
Bank of Taiwan	Price stability, economic growth and exchange rate stability	No
Bank of Thailand	Price stability	Yes, 2000, Core inflation

Hong Kong introduced a currency board in October 1983. The HK dollar (HKD) has been rigidly linked to the USD at the rate of 7.8 HKD/USD since then. This is remarkable given that Hong Kong is an open economy, which has no restriction on capital

flows. Similarly, Singapore also manages the value of the Singapore dollar against other currencies, though its monetary policy objective is explicitly to promote price stability. In 1981, the monetary framework shifted to management of the Singapore dollar against a basket of currencies. As in Hong Kong, though the economy is very open, Singapore has been relatively successful in controlling its inflation, which is always mean reverting. Singapore uses the exchange rate as a stabilisation instrument, much as most other CBS deploy a policy interest rate.

The monetary policy objectives of Taiwan are also to stabilise the movements of the exchange rate, in addition to pursuing long-term price stability and economic growth. The Central Bank of China (CBC) in Taiwan manages its target of M2 through open market operation, discount window, and selling certificate deposit. CBC pursues a managed floating exchange rate and to some extent, allows market forces to shape it. The intervention is held whenever there is an excessive volatility.

2.4. Inflation Persistence

2.4.1. Methodology and Data

There are two approaches to measuring inflation persistence; the univariate and multivariate approaches. In a univariate approach, we regress inflation on its own lags and sum up the coefficients of the lags. If the sum is close to 1, the movement of inflation effectively follows a random walk, and its persistence is high. The multivariate approach is more complex since it includes other variables. Examples of this model include a Phillips Curve equation or a structural VAR or macroeconometric model. The multivariate approach explains inflation persistence in a more comprehensive manner since other variables are included. In this section, we employ the univariate approach because we want

to explore the data generating process of the inflation, rather than its determinants. Another advantage is that the model is free from specification problems.

There are four methodologies to measure inflation persistence in the univariate approach. These are the sum of autoregressive coefficients, the spectrum at zero frequency, the largest autoregressive root, and the half-life. All of the methodologies mentioned are based on the sum of autoregressive coefficients in $AR(p)$ process. Andrew and Chen (1994) discuss the first three. Basically, they argue that the cumulative impulse response function, *CIRF*, is a good scalar measure of persistence. In a simple $AR(p)$ process:

$$y_t = \alpha + \sum_{j=1}^p \beta_j y_{t-j} + \varepsilon_t \quad (2.5)$$

the *CIRF* is simply given by $CIRF = \frac{1}{1-\rho}$, where ρ is the sum of autoregressive coefficients $\rho = \sum_{j=1}^p \beta_j$. We can rewrite (2.5) as follows,

$$\Delta y_t = \alpha + \sum_{j=1}^{p-1} \delta_j \Delta y_{t-j} + (\rho - 1)y_{t-1} + \varepsilon_t \quad (2.6)$$

It is similar in the Augmented Dickey Fuller (ADF) unit root test, where $\delta_j = -\sum_{i=1+j}^p \beta_i$ and ρ is the coefficient of persistence.

The spectrum at zero frequency is measured by

$$h(0) = \frac{\sigma_\varepsilon^2}{(1-\rho)^2} \quad (2.7)$$

where σ_ε^2 is the variance of the residual ε_t and ρ is the sum of autoregressive coefficients. This methodology is equivalent to the sum of autoregressive coefficients if σ_ε^2 is fixed. However, this becomes problematic if we measure the changes of persistence over time. As time changes, not only does ρ change, but also σ_ε^2 .

Another measurement identifies the largest autoregressive root of the $AR(p)$ process. This also has a weakness, since the impulse response is influenced not only by the largest root, but also by the other roots. Comparing only the largest root of two series can lead to misleading conclusions being made (Andrews and Chen, 1994, and Pivetta and Reis, 2001).

The half-life is defined as the number of periods where the effect of the shock attains fifty percent. In a simple $AR(1)$ process, it may be calculated as follows:

$$hl = \frac{\ln(\frac{1}{2})}{\ln(\rho)} \quad (2.8)$$

It is a good measurement, especially for communication purposes since its measurement is in units of time. However, it is criticised if the impulse response function is oscillating, and if the lags are exponential. If so, it can understate or overstate the persistence of the process (Mankiw and Reis, 2002).

Since all of the methodologies are based on the sum of autoregressive coefficients ρ , which is one to one with the *CIRF*, and given the weaknesses of the last three approaches, we will use the sum of autoregressive coefficient to measure the inflation persistence. An important implication of using the *CIRF* is if any estimation of the persistence is conditional on the long run inflation path. That is why this measurement is good for a stable path. Given the occurrence of Asian financial crisis there is a potential for a structural break to occur. It is likely that the inflation process changes. Hence we divide the sample into two by assuming there is only one break that occurs during the crisis period.

We use two methods to determine the break. We call it an automatic structural break, which is based on a statistical test, and arbitrarily (or manual) structural break. The

reason for using statistical methods is to let the data and model specification decide where the break is. This method provides an indication as to which quarter the break happens. Hansen (2001) emphasises that structural change is a statement about parameters. It only has a meaning in the context of a model. Based on that and for the purposes of simplification, we use an $AR(1)$ model for testing the structural break.

For this method, we employ the Andrews-Quandt breakpoint test (Andrews, 1993 and Andrews and Ploberger, 1994). We use this test since we do not know for sure when the break of the inflation process occurred. The Andrews-Quandt test is a sequence of Chow Breakpoint tests given the two moving samples. Since the distribution of these test statistics is non-standard, Andrews (1993) develops their true distribution and Hansen (1997) provides their asymptotic p -values. In the testing standard procedure, we normally exclude the first and the last of the observations. This trimming is done to compensate the behaviour of the distribution. It becomes degenerate when approaching the beginning or the end of the sample. We use standard level trimming of 15 percent, where each 7.5 percent of the sample is excluded in the first and last observation.

We argue that the result of this test is subject to some input in the test itself, such as the percentage of trimming, the specification of the model itself and the number of observations included. For that reason, we also impose the assumption break that arbitrarily falls during the period of 1997Q3 to 1999Q4. As widely known, the crisis started on July 1997 in Thailand when the volatility of macroeconomic variables such as exchange rate increases sharply. Afterwards, the recovery becomes identifiable at the beginning of 2000. Here, we treat the break not as a specific date as in standard statistical methods, but as a period of break. Hence, there are two samples generated; these are 1985Q1 to 1997Q2, and 2000Q1 to 2010Q1. Although it is arbitrary, it is more reasonable

since the countries take time to recover from the crisis. Any change in the economy is unlikely to be immediate, and usually takes time to take effect. Moreover, this arbitrary period of break is often used in practice.

We estimate an $AR(1)$ model for the whole sample and the sub sample for each country based on the structural break above. One may argue that each country or period has a different auto regressive specification, and thus its lags should be different. For that reason, we use the specification of ADF test. The equation in ADF test is a modification of $AR(p)$, where the number of lags (p) is determined through a lag selection criteria, such as Schwarz Information Criterion (SIC). As a result, the number of lags for each country and each period are different. As long as p generated in the ADF test is 1, the persistence is exactly the same as in $AR(1)$ process. ADF test takes this specification.

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \sum_{j=1}^p \beta_j \Delta y_{t-j} + \varepsilon_t \quad (2.9)$$

This specification can be arranged into the form of $AR(p)$ as follows,

$$y_t = \alpha_0 + (1 + \gamma + \beta_1)y_{t-1} + (\beta_2 - \beta_1)y_{t-2} + (\beta_3 - \beta_2)y_{t-3} + \dots + \beta_p y_{t-p} \quad (2.10)$$

We compare the degree of persistence of each country by summing up the coefficient of its lags.

The auto regressive specification above is estimated using OLS. A problem with OLS is, that it is not free from a finite sample bias, when we assume non-normality. To deal with this, we accompany the OLS estimations with a bootstrap method⁷. In short, we will have the estimation of $AR(1)$, $AR(2)$, $AR(p)$, and bootstrap with $AR(1)$ and $AR(2)$ specification.

⁷ This method is developed by Efron (1979). It starts by finding the standard error of one distribution. In bootstrap sample of T observations, each observation that is drawn with replacement has probability of $1/T$. By “with replacement” it is possible one observation comes up more than once. Efron (1979) shows if this experiment is repeated many times then the moments of the bootstrap sample will converge to the moments of population.

We also perform rolling window regressions of $AR(I)$ to confirm the measurement. We estimate rolling regression from 15 point backward of 1985Q1 with the constant sample of 30. However, we can only reach point 2010Q1, which is the end of period, given the constant number of observations in the sample. This method only indicates the evolution of the persistence over time but does not divulge the exact time of the change.

For most of the estimations, we use Consumer Price Index (CPI) as a price variable, not GDP deflator. CPI measures the price of goods and services purchased by consumers. Meanwhile, GDP deflator measures the price of goods and services that are produced domestically. This excludes the price of imported goods. CPI inflation is more relevant for the countries under investigation as all of them use the CPI as the main official measurement of prices. As the CPI includes imported goods, the exchange rate exerts considerable influence on this index and is therefore appropriate in the analysis of ERPT in an open economy. Moreover, it is a target of inflation in the countries that adopt ITF.

From a technical point of view, GDP deflator data are published with lag and are subject to statistical revision. Meanwhile, CPI is published quickly, will have a more immediate impact on inflation expectations and is rarely, if ever, revised. In the case of estimations that use monthly data, the GDP deflator also needs interpolation, subject to the technique used. In this case, CPI is more readily applicable. Since the exchange rate statistics are available at monthly (and higher) frequency, estimated pass through dynamics are much more suited to a monthly index such as CPI, as opposed to something measured in much lower frequency.

We use quarterly data for Consumer Price Index in each country within the period of 1985Q1 to 2010Q1 and transform them into quarter-to-quarter (QtQ) data. The data are taken from the IMF's International Financial Statistics. All the data are stationary in terms

of difference log according to ADF test, except for Korea before the crisis. In this case, we use GDP deflator of Korea for both before and after the crisis, which are stationary, to make it comparable. The ADF test results are in Appendix 2.1.

2.4.2. Estimation Results

2.4.2.1. Inflation Persistence 1985Q1-2010Q1 and Structural Break

We divide section 2.4.2 into two. First, in this subsection we describe the comparison of inflation persistence among the countries for the whole sample and determine the structural break based on the statistical test and the ad hoc of break period. Second, in the next subsection we compare the persistence before and after the break.

The estimation results show that the degrees of persistence are quite different between $AR(1)$, $AR(p)$ and $AR(1)$ with bootstrap, but the sequences are similar. Using QtQ data, Taiwan, Malaysia, Korea, Thailand, and Philippines have low inflation persistence. Meanwhile, Hong Kong, Indonesia, and Singapore have high persistence, above 0.5 according to $AR(1)$ and $AR(p)$.

Table 2.4. Inflation Persistence 1985Q1-2010Q1

Country	Persistence (QtQ)		
	AR(1) OLS	AR(p) OLS	AR(1) Bootstrap
Hong Kong	0.755	0.898	0.432
Indonesia	0.604	0.604	0.230
Singapore	0.514	0.514	0.127
Philippines	0.401	0.373	0.067
Thailand	0.296	0.296	0.022
Korea	0.221	0.221	0.004
Malaysia	0.161	0.161	-0.005
Taiwan	0.002	0.296	-0.014

This difference confirms that measuring the exact numerical estimate of persistence is subjective. The degree of persistence can change according to the specification used to measure it, how many breaks or shift we employ and whether we use QtQ or YoY data. For example, some authors such as Levin and Piger (2002) and Cecchetti and Debelle (2006) demonstrate that high persistence occurs when we do not allow a shift in the mean of inflation. By imposing the shift, the coefficient of the lags becomes smaller.

We assume there is a structural break given the Asian crisis. The crisis started in July 1997. We assume the recovery was operating from the beginning of 2000. Based on this, we assume that the break occurs during that period and re-estimates the models. By re-estimating each sub sample separately, we assume not only that the intercept changes but also so does the coefficient of persistence.

Table 2.5. Andrews-Quandt Structural Break Test Results

Country	Quarter of Break (QtQ)		Quarter of Break (YoY)
Hong Kong	1998Q3	*	1999Q4
Indonesia	1998Q4	*	1999Q1 *
Korea	1998Q2	*	1998Q3
Malaysia	1999Q2		1999Q1
Philippines	1999Q2		1999Q2
Singapore	1997Q4	*	1999Q1
Taiwan	1996Q4		1997Q1
Thailand	1998Q3		1998Q3

* Statistically significant at ten percent using Andrews Ploberger critical value. We use Andrews-Quandt test to calculate the breaks with trimmed 15% and the specification is AR(1)

The results of the Andrews-Quandt test show that the breaks fall within the period of the crisis. However, not all the test results reject the null hypotheses that there is no break point. Malaysia, Taiwan and Thailand do not show significant results. This implies

that the crisis in these countries do not generate a structural break in terms of inflation. If we use year on year data, only Indonesia shows a significant break. That is reasonable since the year on year data are smoother and only Indonesia shows extreme inflation during the crisis.

2.4.2.2. Inflation Persistence Pre and Post Crisis

Given the break, both from the automatic test and the manual way, we estimate $AR(1)$, $AR(2)$ and $AR(p)$ for each sample. We employ OLS and bootstrap for the $AR(1)$ and $AR(2)$ model. From the result, we measure the inflation persistence by taking up the coefficients of the lags. Before examining the degree of persistence, we look at the difference of the means of the two samples.

Table 2.6. Inflation Means (YoY)¹ Pre and Post Crisis

Country	Manual structural break ²			Automatic structural break ³		
	Pre Crisis	Post Crisis	difference ⁴	Pre Crisis	Post Crisis	difference ⁴
Singapore	1.76	1.42	0.34	1.63	1.35	0.28
Malaysia	2.73	2.19	0.54	2.90	2.20	0.70
Taiwan	2.68	0.98	1.70	2.73	0.96	1.77
Thailand	4.31	2.49	1.82	4.60	2.35	2.25
Korea	5.43	3.11	2.32	5.51	2.97	2.54
Indonesia	7.76	8.36	-0.60	11.30	8.68	2.62
Philippines	9.87	4.83	5.04	9.75	4.84	4.91
Hong Kong	7.83	-0.10	7.93	6.83	-0.10	6.93

1. We calculate the mean by averaging the year on year inflation of each samples

2. The break is determined manually or arbitrarily using the period of crisis 1997Q3 to 1999Q4 as a result the pre crisis sample is 1985Q1-1997Q2 and the post crisis sample is 2000Q1-2010Q1

3. The break is based on Andrews-Quandt test that refer to a specific quarter.

4. Positive means declining

Given both break approaches, we find that all countries experience lower inflation means after the break in year on year inflation data. The sequence from the lowest to the highest difference does not change. Singapore experiences the lowest change and Hong Kong shows the biggest decrease after the break. Only Indonesia shows ambiguity. Its

inflation decreases if we separate the sample by the crisis period. However, it slightly increases if we impose an exact break at 1999Q1, which is significant. The reason for this is that when we impose 1999Q1 as a break, the highest inflation occurred at 1998Q3 that included in the sample before the break. When we impose the crisis period as a break, the increase is due to the highest inflation during the oil price shock in 2005. This also happens when we check its mean in QtQ data.

Table 2.7. Inflation Persistence Pre and Post Crisis AR(1) (YoY)

Country	Method	Manual structural break ¹			Automatic structural break ²			Date of Break
		Pre Crisis	Post Crisis	difference ³	Pre Crisis	Post Crisis	difference ³	
Hong Kong	AR(1) OLS	0.968	0.913	0.056	1.093	0.913	0.180	1999Q4
	AR(1) Bootstrap	0.912	0.766	0.146	1.019	0.766	0.253	
Indonesia	AR(1) OLS	0.689	0.785	-0.097	1.222	0.467	0.754	1999Q1*
	AR(1) Bootstrap	0.288	0.500	-0.212	1.210	0.355	0.855	
Korea	AR(1) OLS	0.899	0.711	0.188	0.884	0.599	0.285	1998Q3
	AR(1) Bootstrap	0.741	0.415	0.326	0.693	0.331	0.361	
Malaysia	AR(1) OLS	0.869	0.762	0.107	0.895	0.748	0.147	1999Q1
	AR(1) Bootstrap	0.658	0.428	0.230	0.670	0.413	0.257	
Philippines	AR(1) OLS	0.687	0.759	-0.072	0.684	0.753	-0.069	1999Q2
	AR(1) Bootstrap	0.596	0.438	0.157	0.593	0.432	0.160	
Singapore	AR(1) OLS	0.925	0.864	0.061	0.960	0.857	0.102	1999Q1
	AR(1) Bootstrap	0.790	0.652	0.138	0.788	0.619	0.169	
Taiwan	AR(1) OLS	0.804	0.740	0.064	0.803	0.677	0.126	1997Q1
	AR(1) Bootstrap	0.517	0.433	0.084	0.527	0.306	0.221	
Thailand	AR(1) OLS	0.802	0.755	0.046	0.906	0.707	0.199	1998Q3
	AR(1) Bootstrap	0.623	0.441	0.182	0.668	0.440	0.229	

1. The break is determined manually or arbitrarily using the period of crisis 1997Q3 to 1999Q4 as a result the pre crisis sample is 1985Q1-1997Q2 and the post crisis sample is 2000Q1-2010Q1

2. The break is based on Andrews-Quandt test that refers to a specific quarter.

3. Positive means declining

* the break is statistically significant at ten percent based on Andrew Ploberger critical value

Table 2.7, 2.8, and 2.9 present the inflation persistence measures before and after the break in year on year data. These values are based on $AR(1)$ and $AR(2)$ specification with OLS and using bootstrapping, and based on $AR(p)$ specification with OLS. For a further check on robustness, we also estimate the same specification with QtQ data. The results are available in Appendix 2.3.

Table 2.8. Inflation Persistence Pre and Post Crisis AR(2) (YoY)

Country	Method	Manual structural break ¹			Automatic structural break ²			Date of Break
		Pre Crisis	Post Crisis	difference ³	Pre Crisis	Post Crisis	difference ³	
Hong Kong	AR(2) OLS	0.948	0.907	0.041	1.093	0.913	0.180	1999Q4
	AR(2) Bootstrap	0.905	0.775	0.131	1.044	0.775	0.270	
Indonesia	AR(2) OLS	0.631	0.694	-0.063	1.075	0.652	0.423	1998Q4**
	AR(2) Bootstrap	0.288	0.502	-0.214	1.088	0.486	0.602	
Korea	AR(2) OLS	0.882	0.666	0.216	0.845	0.713	0.132	1999Q1
	AR(2) Bootstrap	0.757	0.404	0.353	0.694	0.281	0.412	
Malaysia	AR(2) OLS	0.861	0.575	0.285	0.869	0.586	0.283	1999Q1
	AR(2) Bootstrap	0.740	0.308	0.432	0.731	0.403	0.328	
Philippines	AR(2) OLS	0.756	0.620	0.135	0.755	0.633	0.122	1999Q2
	AR(2) Bootstrap	0.563	0.387	0.177	0.565	0.370	0.195	
Singapore	AR(2) OLS	0.891	0.765	0.126	0.900	0.778	0.122	1999Q1
	AR(2) Bootstrap	0.796	0.668	0.127	0.796	0.614	0.182	
Taiwan	AR(2) OLS	0.830	0.667	0.163	0.829	0.673	0.156	1999Q2
	AR(2) Bootstrap	0.667	0.430	0.236	0.657	0.421	0.236	
Thailand	AR(2) OLS	0.802	0.755	0.047	0.892	0.637	0.255	1998Q3*
	AR(2) Bootstrap	0.702	0.359	0.343	0.748	0.386	0.361	

1. The break is determined manually or arbitrarily using the period of crisis 1997Q3 to 1999Q4

as a result the pre crisis sample is 1985Q1-1997Q2 and the post crisis sample is 2000Q1-2010Q1

2. The break is based on Andrews-Quandt test that refer to a specific quarter.

3. Positive means declining

* (**) the break is statistically significant at ten (five) percent based on Andrew Ploberger critical value

Table 2.9. Inflation Persistence Pre and Post Crisis AR(p) (YoY)

Country	Method	Manual structural break ¹			Automatic structural break ²			Date of Break
		Pre Crisis	Post Crisis	difference ³	Pre Crisis	Post Crisis	difference ³	
Hong Kong	AR(p)	0.948	0.913	0.035	1.034	0.913	0.121	1999Q4
Indonesia	AR(p)	0.689	0.612	0.077	0.246	0.550	-0.304	1999Q1**
Korea	AR(p)	0.922	0.711	0.211	0.893	0.300	0.592	1998Q3
Malaysia	AR(p)	0.869	0.727	0.142	0.895	0.753	0.141	1999Q1
Philippines	AR(p)	0.721	0.487	0.235	0.719	0.544	0.175	1999Q2
Singapore	AR(p)	0.891	0.875	0.016	0.900	0.897	0.003	1999Q1
Taiwan	AR(p)	0.804	0.439	0.365	0.803	0.391	0.412	1997Q1
Thailand	AR(p)	0.802	0.633	0.168	0.943	0.637	0.306	1998Q3

1. The break is determined manually or arbitrarily using the period of crisis 1997Q3 to 1999Q4

as a result the pre crisis sample is 1985Q1-1997Q2 and the post crisis sample is 2000Q1-2010Q1

2. The break is based on Andrews-Quandt test that refer to a specific quarter.

3. Positive means declining

** the break is statistically significant at ten percent based on Andrew Ploberger critical value

We also conduct rolling regressions to accompany this examination. We estimate the specification of $AR(1)$ using OLS for fifteen quarters from 1981Q1 backwards. The sample of thirty observations moves each quarter, until the sample reach 2010Q1 as the last observation, thus we have 88 regression results. However, most of the results do not clearly show whether the inflation persistence declines before and after the crisis. Only Korea exhibits declining trends in both YoY and QtQ data. The results are in Appendix 2.4 and 2.5.

In summary, the main result of this section is that most countries under investigation experience lower average of inflation and lower inflation persistence after the crisis period. Only Indonesia shows ambiguity and this depends on where the break falls if we use a specific quarter as the position of structural break. The possible explanation of the change of inflation persistence is as follows. During the Asian crisis, the exchange rates of some of the countries under investigation experienced both sharp and repeated depreciation, especially in the case of Indonesia. Following this sharp depreciation, inflation expectations also increased substantially and as a result inflation persistence also rose. The influence depends on the size of any secondary exchange rates changes during the crisis.

However, the Asian crisis also brought about several reforms in the economy of the countries examined in this chapter. After the crisis, the demand for transparent policies and information availability also increased. In terms of monetary policy, some governments responded to this by adopting a new monetary policy regime, ITF, which provided more transparency and accountability. These reforms influenced the behaviour of price setters. In general, they become more forward looking in setting their prices, which may have reduced inflation persistence. These two factors, the sharp exchange rate depreciation

during the crisis and more transparent monetary policy after the crisis, affected inflation persistence in contrasting directions. They may also have made inflation persistence in Indonesia higher by some estimates, while other countries experienced lower inflation persistence after the crisis. Indonesia experienced the sharpest depreciation during the crisis and was also the last of the four to implement ITF.

2.5. Exchange Rate Pass Through

2.5.1. Methodology

We estimate the model before and after the Asian crisis as in the inflation persistence section. In this case, we only use the arbitrary break so that the samples estimated are 1985Q1 to 1997Q2 and 2000Q1 to 2010Q1. We do not use automatic or statistical tests to find the structural break for two reasons. First, the crisis period takes lasts longer than one quarter. Second, we deal with different equations, in particular the number of lags included for different periods of sample. Technically, it is not applicable since we need the same equation to test the structural break (Hansen, 2001).

In this study we follow a theoretical background of ERPT in Campa and Goldberg (2005). They measure the ERPT into the import price for 23 OECD countries. Import price is the translation of export price of trading partner's country $P_t^m = P_t^x/E$, where E is exchange rate, in terms of foreign currency over domestic currency. Taking the logarithm (depicted in lower case):

$$p_t^m = p_t^x - e_t \quad (2.11)$$

The price of export p_t^x itself is determined by two factors: mark up price (mu_t) and marginal cost (mc_t) of the exporter.

$$p_t^x = mu_t + mc_t \quad (2.12)$$

Substituting (2.12) into (2.11), we get

$$p_t^m = mu_t + mc_t - e_t \quad (2.13)$$

$$mu_t = \alpha_0 - \alpha_1 e_t \quad (2.14)$$

In this model mark up price is determined by two components. The first component (α_0) captures the specific effect of industry associated with the competition. This is unrelated to the movement of exchange rate. The second component (α_1) varies with the movement of exchange rate. In one extreme, the mark up will not respond to the exchange rate fluctuation; the exporter just translates the exporter cost into the import price fully. This generates a complete pass through and reflects the producer currency pricing. Another extreme is when the exporter absorbs the fluctuation fully within the mark up, and thus it is independent of the exchange rate. In this case, the exporter conducts local currency pricing or pricing to market.

On the other hand, the marginal cost is determined by the demand of the importing country (y), labour's wage (w), the commodity price (cp) in terms of foreign currency, and the exchange rate (e_t).

$$mc_t = \gamma_0 y_t + \gamma_1 w_t + \gamma_2 cp_t - \gamma_3 e_t \quad (2.15)$$

Substituting (2.14) and (2.15) into (2.13), we get

$$p_t^m = \alpha_0 - \beta_0 e_t + \gamma_0 y_t + \gamma_1 w_t + \gamma_2 cp_t \quad (2.16)$$

where $\beta_0 = 1 + \alpha_1 + \gamma_3$ is the ERPT into the import price. The last three variables (y, w , and cp) are the variables that determine the cost of supplying to the domestic market, and this cost is equal to the opportunity cost of providing the same goods to the other markets. Assuming the market is integrated worldwide, this opportunity cost is reflected in the world price (p^*). Given that, (2.16) is rewritten:

$$p_t^m = \alpha_0 - \beta_0 e_t + \gamma p^* \quad (2.17)$$

We shall use the idea behind this specification to form the basis of our empirical model to measure the ERPT, both to import price and to CPI. Some empirical studies on ERPT (e.g. Edwards 2006; Gagnon and Ihrig 2004; Campa and Minguez, 2006) also adopt a variant of the above model. Hence, our empirical model is as follows:

$$\log P_t = \beta_0 + \beta_1 \log E_t + \beta_2 \log P_t^* + \varepsilon_t \quad (2.18)$$

Where P is the price index, whether this refers to import price or consumer price, E is the exchange rate, P^* is the foreign price index, and ε is the disturbance term. In this equation, β_1 is the long run exchange rate pass through. It is expected to have a negative sign if we use the exchange rate in terms of the foreign currency value of domestic currency. This implies that depreciation increases inflation. Some empirical studies impose restriction $\beta_1 = \beta_2$ to reflect the elasticity of import price to domestic price. In this study, we employ the general form where β_1 and β_2 are unrestricted.

In this equation we have a problem, with all the variables in terms of level, not non-stationary (not $I(0)$). As Granger and Newbold (1974) emphasise; an estimation of non-stationary variables results in a spurious regression. To avoid this, the equation needs to be converted into an error correction (ECM) model, which is a short run dynamic model using variables in difference to guarantee the variables are stationary. This equation is completed with the long run relationship among the variables as in (2.18). However, to confirm the existence of this long run relationship, we need to test for cointegration and if it exists we have an ECM model. This ECM model captures the short term and the long term relationship and also informs us of the speed of adjustment from the short term to the long term.

There are some methods for checking for the existence of cointegration. Take for example, Engle and Granger (1987), Johansen (1988) Pesaran et al. (2001). Kremmers et al. (1992) show that finding a cointegration using Engle and Granger (1987) approach is inferior to ARDL with ECM. While Kremmers et al. (1992) criticise Engle and Granger's (1987) procedure, Pesaran and Shin (1995) propose an ARDL cointegration approach. Unlike the Johansen method, which deals with a system of equation, this method is applicable to a single equation model. The variables in the long run specification also do not need to have the same integration. We can proceed with $I(1)$ and $I(0)$ or a mix. In Engle and Granger's (1987) study, the residual of the long run equation should be $I(0)$ and the variables should be $I(1)$. However, we still need to test the degree of integration to ensure that none of the variables is greater than $I(1)$ process. If we find an $I(2)$ variable, we should turn to the concept of multi cointegration or difference the variables twice. Another advantage of ARDL cointegration approach is that it is suitable for the estimation with a limited sample, which is important and relevant to this study.

Equation (2.18) has a problem of endogeneity if we add lags of dependent variable. The lag of dependent variable is automatically correlated with the disturbance. In addition, the exchange rate may be correlated with the disturbance term too. There are some methods for resolving this problem. The first is to find instrumental variables that bear a close relationship with the exchange rate, but have no correlation with the disturbance term. This method includes Generalized Method of Moments (GMM) and Two Step or Three Steps Least Square (TSLS) estimation. We can also create a simultaneous equation and estimate it with Seemingly Unrelated Regression (SUR). Second, we can estimate a structural Vector Auto Regression (VAR) model. Third, we can employ an Auto Regressive Distributed Lag (ARDL) approach.

Meese and Rogoff (1983) underline the fact that it is difficult to find instrumental variables for the exchange rate. Moreover, for the case of developing countries, the availability of indicator related to the exchange rate is limited. Structural VAR also has a disadvantage where we need to convince the timing of the exchange rate effect to the inflation. Furthermore, most previous researches on ERPT use this method. Due to these reasons, we employ an ARDL approach where we can use least square methods to estimate the equation. The ARDL estimation is applicable if the explanatory variables are endogenous, provided that the order of the ARDL model is appropriately augmented (Pesaran and Shin, 1995). This approach allows for contemporaneous correlations between the stochastic components of the data generating processes included in the estimation.

Taking the above factors into consideration, we conduct the ARDL cointegration approach. Pesaran, Shin and Smith (2001) document the procedure and the critical value of the bound test. First, we estimate an ARDL model in log level, which is as follows:

$$\log P_t = \theta_0 + \sum_{i=1}^{p1} \gamma_{1i} \log P_{t-i} + \sum_{i=0}^{p2} \gamma_{2i} \log E_{t-i} + \sum_{i=0}^{p3} \gamma_{2i} \log P_{t-i}^* + \varepsilon_t \quad (2.19)$$

We determine the lag of *ARDL* ($p1, p2, p3$) model in log level based on methods such as Schwarz Bayesian Criteria (SBC) or Akaike Information Criteria (AIC). Initially, we determine the maximum lag that is reasonable. In this case, we assume the maximum lag is four quarter backwards, which implies that the influence of exchange rate to price is no more than four quarters. Another reason is using too many lags as this will sacrifice the degree of freedom given the limited sample that we have. We then estimate combinations of the lags that match the lag criteria in the ARDL equation. Then we convert *ARDL* ($p1, p2, p3$) into (2.20) or what is called the ARDL conditional ECM and test the null hypotheses to ensure that there is no level effect.

$$\Delta \log P_t = \alpha_0 + \alpha_1 \log P_{t-1} + \alpha_2 \log E_{t-1} + \alpha_3 \log P_{t-1}^* + \sum_{i=1}^{p_1} \gamma_{1i} \Delta \log P_{t-i} +$$

$$\sum_{i=0}^{p_2} \gamma_{2i} \Delta \log E_{t-i} + \sum_{i=0}^{p_3} \gamma_{3i} \Delta \log P_{t-i}^* + \varepsilon_t \quad (2.20)$$

$$H_0: \alpha_1 = \alpha_2 = \alpha_3 = 0$$

$$H_a: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq 0$$

We perform a bound test, where there are two sets of critical values; one set refers to the $I(1)$ series and the other for the $I(0)$ series. The critical value of $I(0)$ refers to the lower bound and that of $I(1)$ refers to the upper bound. If the statistical value, which follows F distribution, falls above the upper bound, the test rejects the null hypotheses that there is no cointegration. Conversely, if it falls below the lower bound, the test accepts that there is no cointegration. Meanwhile, it is inconclusive if the statistical value falls between the bound. If there is a cointegration, then equation (2.20) is re-arranged into a common ECM form as follows.

$$\Delta \log P_t = \alpha_0 + \sum_{i=1}^{p_1} \gamma_{1i} \Delta \log P_{t-i} + \sum_{i=0}^{p_2} \gamma_{2i} \Delta \log E_{t-i} + \sum_{i=0}^{p_3} \gamma_{3i} \Delta \log P_{t-i}^* + \delta(\log P_{t-1} + \beta_0 + \beta_1 \log E_{t-1} + \beta_2 \log P_{t-1}^*) + \varepsilon_t \quad (2.21)$$

Where $\beta_0, \beta_1, \beta_2$ are the long run coefficients, in particular β_l is the ERPT in the long run. The ERPT in this model implies the long run relationship between the exchange rate and the CPI or the import price. Meanwhile, the coefficient of δ is the speed of adjustment of the correction of the short run behaviour into the long run behaviour. The value of δ is between -1 and 0, and the greater $|\delta|$ the faster the correction.

If we do not find the cointegration, we proceed with the standard ARDL model with variables in log difference as follows:

$$\Delta \log P_t = \alpha_0 + \sum_{i=1}^{p_1} \gamma_{1i} \Delta \log P_{t-i} + \sum_{i=0}^{p_2} \gamma_{2i} \Delta \log E_{t-i} + \sum_{i=0}^{p_3} \gamma_{3i} \Delta \log P_{t-i}^* + \varepsilon_t \quad (2.22)$$

The specification in (2.22) follows the model in Campa and Goldberg (2005), where the ERPT is calculated by $\frac{\sum_{i=0}^{p_2} \gamma_{2i}}{1 - \sum_{i=1}^{p_1} \gamma_{1i}}$. These authors do not find a cointegration relationship among the variables of 23 OECD countries and call the coefficient the long run ERPT. The appropriateness of Campa and Goldberg's (2005) term *long-run* pass-through for equation (2.22) is debatable. According to Aron et al. (2010), the sum of these coefficients is not the long run pass-through but the *cumulative* n -period pass-through where n varies with the number of lags in the ARDL model. We follow Aron et al. (2010) and interpret the ERPT in equation (2.22) as the *cumulative* or *full* pass-through of the exchange rate into inflation. In our case, for each country, to make the two sub-periods comparable we use either specification (2.21) or (2.22) both before and after the crisis, regardless of the cointegration test results. For instance, if we find that there is cointegration before the crisis but not after, then we use the specification (2.22) for both sub-periods. On the other hand, if we find cointegration in both sub-periods, we then use specification (2.21) for both of these sub-periods.

Furthermore, we impose a restriction that the summation of the exchange rate coefficients in equation (2.22) are equal to zero, $\sum_{i=0}^{p_2} \gamma_{2i} = 0$. We perform a Wald test to check the significance of this restriction. We also perform diagnostic tests to confirm whether the equation (2.21) or (2.22) is consistent with the assumption of classical regression. This specification usually passes the serial correlation test, given that the model is specified to deal with that problem. We perform this procedure using Microfit 5.0.

2.5.2. Data

The sources of data are the International Financial Statistics (IFS) of the International Monetary Fund (IMF), Bank for International Settlement (BIS), and OECD

for the sample from 1985Q1 to 2010Q1. We divide the sample before and after the crisis, using manual or arbitrary break, the same as in the inflation persistence section. Thus, we have two samples to compare: 1985Q1-1997Q2 and 2000Q1-2010Q1.

The series involved in the estimations are the CPI, import price index, exporting country price index and nominal effective exchange rate, henceforth NEER. We use an alternative of CPI, such as the GDP deflator, if the log difference of the CPI is non-stationary. For an alternative to NEER, we use a nominal exchange rate in terms of USD over local currency, depending on the availability of the data and the result of the unit root test. For Hong Kong, Korea, Philippines and Singapore, we use NEER. For Indonesia, Taiwan and Thailand, the NEER data are only available after 2000. As we compare the ERPT before and after the crisis, which involves data from before 2000, in order to preserve comparability, we use a series for nominal exchange rate in terms of USD over local currency which is available before and after the crisis. For Malaysia, we do not use NEER, as the data are non-stationary. A rise in the exchange rate indicates appreciation. Meanwhile, the import price index of the IFS is constructed from survey data directly from the importer, which is called direct pricing.

As described in equation (2.17), we need a foreign price index as a proxy of the opportunity cost of providing the same goods to the other markets, including the domestic market of each exporting country. Assuming that the market is integrated worldwide, this opportunity cost is reflected in the world price (p^*) in particular the price in related countries. Hence, we need the proxy of this variable. For that we construct a composite derived from domestic price (either PPI or WPI) of country's main trading partners. We take PPI/WPI index from the IFS (line 75 or 76 of the IFS) that are produced from the price survey to the exporter or importer. For the case of China, we cannot find sufficient

series of the PPI for China so we use CPI to replace it. We construct China's CPI using combination of CPI from OECD and its inflation (YoY) available in IFS, since there is no CPI available in IFS.

The weights in these composites are based on the proportion of the import. Each country will have different weights given different importing countries. Moreover, the import structure of a country is different for each period so that we can also use different weights for different sample periods. For example, most of the countries import from China after the crisis period (2000Q1-2010Q1). Meanwhile, the import portion from China is trivial before the crisis. This difference will generate different weight. We construct the index using fixed weights, which is based on the average fraction of import from the main importing countries. In addition, we also construct an index with moving weights, however the results are quite similar. We present the results that use the index with constant weights in the estimation.

We pick importing countries that in total have more than a fifty percent import share in each period of sample. Ideally, we use all importing countries. However, when using fifty percent threshold, we find that the main importing countries are relatively the same and already represent the main import, in a way that adding other countries does not has a significant effect. Another reason is including more countries has a risk in terms of the data adequacy of some countries. Using the fifty percent threshold, we include at least five main countries trading partners. For the composite of Taiwan, we use the US CPI as the proxy for the world price since we cannot find the data for importing countries of Taiwan.

We perform the ADF unit root test of all the series involved for the two samples: before and after the crisis. The series of prices are seasonally adjusted. We evaluate

whether the series are I(1) at least at ten percent significance level. Based on this unit root test, we use the alternative to the series. For instance, the t statistic of the ADF test for the log difference of CPI of Korea before the crisis, cannot reject the series has a unit root at ten percent significance level, imply the original series is I(2). Hence we use the GDP deflator to replace that series for both before and after the crisis. We also find that NEER data for some countries are completely unavailable, so that we use nominal exchange rate in terms of USD over the local currency. The ADF test results are shown in Appendix 2.1.

2.5.3. Estimation Results

Our main focus is to estimate the ERPT to consumer price, since it links closely to another objective of this chapter: the role of ITF to two aspects of inflation dynamics and; the inflation persistence of CPI and ERPT. In addition, we can only compare the ERPT to consumer price due to availability of data. For instance, we cannot estimate the ERPT to import price of Malaysia and Philippines due to the data availability. For the same reason, we can only estimate for the post crisis period, for Indonesia.

Table 2.10. Results of Bound Test

Country	ERPT into Import Price		ERPT into CPI	
	Pre Crisis	Post Crisis	Pre Crisis	Post Crisis
Hong Kong	1.364	3.772	1.577	14.982 **
Indonesia	NA	1.955	0.472	3.534
Korea ¹⁾	10.317 **	2.740	2.310	0.246
Malaysia	NA	NA	6.274 **	7.207 **
Philippines	NA	NA	15.239 **	2.606
Singapore	21.911 **	8.678 **	1.106	10.903 **
Taiwan	4.963 *	1.635	2.172	3.796
Thailand	2.718	4.957 *	3.619	2.014

1) For Korea, its CPI is replaced by GDP deflator

**, * implies the statistical test are significant at 5% and 10% respectively

First of all, we check the existence of a long run relationship, as shown in equation (2.20) using the bound test for both ERPT into CPI and ERPT into import price. If the test

rejects the null hypotheses there is no cointegration then the proper specification is ECM. Otherwise, we proceed with the ARDL model with first differenced. The results of the bound test show that not all countries or periods display a long run relationship as in equation (2.18); at least at a five percent significant level. For the ERPT to import price, we find that only Singapore has a long run level relationship for both samples. For the ERPT to CPI, only Malaysia has a long run relationship for both samples. However, the ECM form of the equation for Malaysia shows a positive coefficient of speed adjustment. Given these results, we can only compare the long run relationship as in equation (2.20) for the ERPT to import price of Singapore. For other countries we continue with the estimation of equation (2.22) to make it comparable between the two subsamples. This means that we calculate the cumulative or full pass through, not the long run pass through (Aron et al., 2010). We also perform standard diagnostic tests including tests for serial correlation, heteroskedasticity, normality, and specification test.

Table 2.11. Exchange Rate Pass Through

Country	ERPT into Import Price		ERPT into CPI	
	Pre Crisis	Post Crisis	Pre Crisis	Post Crisis
Hong Kong	-0.232 ***	-0.267 **	-0.094	0.052
Indonesia	NA	-0.212 ***	-0.068 **	-0.021
Korea	-0.477 ***	-0.589 ***	-0.129 ***	-0.008
Malaysia	NA	NA	0.061	-0.184 **
Philippines	NA	NA	-0.163 **	-0.056
Singapore	-0.470 *** ¹	-0.180 ¹	0.094 **	-0.192
Taiwan	-0.544 ***	0.013	-0.063	0.165 ***
Thailand	-0.069	-1.009 ***	0.049	-0.019

***, **, * are significantly different from zero at 1%, 5%, and 10% respectively

Using Restriction the summation of the coefficients of the exchange rate is equal to zero (Wald test)

1. The value is based on the estimation of equation (2.21), otherwise based on equation (2.22)

We find that the ERPT to import price is higher than the ERPT into CPI. This is as expected, since the influence of the exchange rate decreases as the local cost increases.

This is also reflected in the significance of the coefficients. There are more significant coefficients in the ERPT to import price's equation. Moreover, the goodness of fit of the model, which is shown on adjusted R^2 , is generally higher. That means that the behaviour of exchange rate and foreign price can explain the behaviour of import price better than that of consumer price.

From the ERPT to import price, we find the signs of the coefficients are as expected, except for those for Taiwan after the Asian crisis. However, this coefficient is insignificant. Singapore also has an insignificant coefficient after the crisis. It may suggest that their exchange rate is managed more significantly and thus the changes are not so influential. This is shown on the volatility of the exchange rate; after the crisis, the standard deviation of these two countries' exchange rate is less than before the crisis. On the other hand, before the crisis, Thailand has an insignificant coefficient, implying that the role of exchange rate in import prices is insignificant. After the crisis, the ERPT into import price is significant and relatively high in magnitude. It may be due to the fact that Thailand's exchange rate is managed less effectively after the crisis, in line with the implementation of the ITF. The ERPT to import price of Hong Kong is significant for the two sub samples. Hong Kong implements a Currency Board System that pegs its exchange rate to the USD. We expect that the elasticity of its nominal exchange rate in terms of the USD is insignificant. As we use its nominal effective exchange rate, this suggests that its exchange rate is fixed to the USD and that it floats vis-a-vis other currencies.

On the other hand, the coefficients of ERPT to CPI are less clear, as there are more insignificant coefficients and more coefficients have unexpected signs. Some countries have positive signs though some are insignificant. This implies that appreciation induces inflation. Hong Kong and Taiwan have positive signs after the crisis. Malaysia and

Thailand have positive signs before the crisis. Regardless of the significance of the coefficients, out of the countries that have negative signs in both periods, three countries experience a decrease of the second pass through in terms of the magnitude. These countries are Indonesia, Korea and Philippines. Korea experiences the smallest decline, followed by Indonesia, and Philippines. If we make comparisons amongst the countries, the results also suggest that a country that still controls and manages its exchange rates tends to have a positive sign.

From the results above, it is clear that some countries have a coefficient of ERPT close to minus one or less than minus one, either to import price or to CPI. One possible explanation is that depreciation that induces export, increases the demand for non-traded good. This eventually increases inflation. As exports increase, the trade balance moves towards surplus. This increases foreign reserves so that money supply will also tend to increase. Higher supply of money leads to high demand for traded good until the surplus diminishes. Overall, this results in the proportional increase in price (Neary, 1980).

The result of inflation persistence shows that most ITF countries experienced a decline in inflation mean and inflation persistence after the crisis. On the other hand, the result of ERPT estimation is less clear. However, it is an interesting result that is worth noting: Among the countries under investigation, some ITF countries such as Indonesia, Korea, and Philippines, experienced declining ERPT, in particular the ERPT to CPI. Even the coefficients after the crisis are insignificant, which implies that the role of exchange rate is diminishing. This finding could support the argument of Taylor (2000) who claims that a more stable monetary condition and well-anchored inflation expectation, leads to lower ERPT. In this case, the implementation of ITF after the crisis, brings about a more stable monetary condition and provide a well anchored inflation. However, it cannot be

concluded from this section whether ITF specifically plays a significant role in this change. We shall scrutinise this in the next section.

2.6. The Role of ITF

2.6.1. Methodology and Data

In the previous sections, we demonstrated that most countries experienced lower inflation means and persistence after the crisis, regardless of whether the country adopted ITF or not. In terms of ERPT, some ITF countries also experienced a decline in ERPT though the results are less clear. In this section we answer the third research question: whether the adaption of ITF influences these changes.

In the previous section, we estimated the equations into two separate periods: pre and post crisis. In the post crisis period, we ignore the date when a country adopted ITF, since all countries practically place inflation as the main objective of in their monetary policy. In this section, we still use the model based on the theoretical background for ERPT. The data we use are the same as in the previous section. We conduct an estimation for each ITF country separately using a standard ARDL approach. Instead of dividing the sample, we estimate the whole sample with the dummy crisis and plug the dummy ITF in each regressor, following Edwards (2006), to check the role of ITF. As we are concerned with the role of the monetary policy to overall price, we use CPI as the dependent variable. We use the specific time of adopting ITF by each country to construct the ITF dummy variables. Hence, we can capture the effect of adopting ITF specifically to confirm our conjecture. After all, we still include dummy variables to capture the crisis period.

The steps taken are as follows: First, we estimate the ARDL model using the variables in log difference. Based on this, we determine the proper lag based on Schwarz

Bayesian Criteria (SBC). Second, we impose dummy ITF for each regressor and its lags. Hence, the final model will be as follows:

$$\Delta \log P_t = \alpha + \sum_{i=1}^{p_1} \beta_{1i} \Delta \log P_{t-i} + \sum_{i=1}^{p_1} \beta_{2i} \Delta \log P_{t-i} ITF + \sum_{i=0}^{p_2} \gamma_{1i} \Delta \log E_{t-i} + \sum_{i=0}^{p_2} \gamma_{2i} \Delta \log E_{t-i} ITF + \sum_{i=0}^{p_3} \theta_{1i} \Delta \log P_{t-i}^* + \sum_{i=0}^{p_3} \theta_{2i} \Delta \log P_{t-i}^* ITF + \rho D_t \quad (2.23)$$

We calculate inflation persistence from $\sum_{i=1}^{p_1} \beta_{1i}$ and $\sum_{i=1}^{p_1} \beta_{1i} + \sum_{i=1}^{p_1} \beta_{2i}$ for pre and post ITF respectively. For the full ERPT we calculate from $\frac{\sum_{i=1}^{p_2} \gamma_{1i}}{1 - \sum_{i=1}^{p_1} \beta_{1i}}$ and

$\frac{\sum_{i=1}^{p_2} \gamma_{1i} + \sum_{i=1}^{p_2} \gamma_{2i}}{1 - (\sum_{i=1}^{p_1} \beta_{1i} + \sum_{i=1}^{p_1} \beta_{2i})}$ for pre and post crisis respectively. We expect the coefficients of dummy ITF for persistence (β_{2i}) to be negative and significant, and that for the exchange rate (γ_{2i}) are positive and significant. This indicates that the inflation persistence and the ERPT decline after implementation of ITF. On the other hand, if the dummies of the ITF are not significant, there it is not viable to conclude that the ITF plays a significant role in reducing the inflation persistence and the ERPT. To confirm whether the coefficients of pre and post ITF are the same or not, we perform a Wald test. In particular, we impose a restriction whether $\sum_{i=1}^{p_1} \beta_{2i} = 0$ for the inflation persistence and whether $\sum_{i=1}^{p_2} \gamma_{2i} = 0$ for the ERPT. If the Wald test cannot reject the null hypotheses that the coefficients are equal to zero, then the coefficient with dummy ITF can be ignored. This implies that there is no impact of the ITF on inflation persistence and ERPT.

2.6.2. Estimation Results

Before estimating, we perform a unit root test for all variables involved. The ADF tests conclude that all variables in log difference are $I(0)$ or stationary. The results of the ADF test are provided in Appendix 2.1. For the maximum lags, we assume the effect of the

exchange rate movement to domestic inflation is four lags. Based on Schwarz Bayesian Criteria (SBC), some combinations of lag for each variable are evaluated. Given this criteria, each country's model has different specification of lags. We impose dummy ITF for each regressor and its lags and evaluate their coefficients. We also perform diagnostic tests to check the assumption of the ordinary least square. The complete estimation results are provided in Appendix 2.6. We display the summary as in Table 2.13. The coefficients in this summary are calculated based on the magnitude of the coefficients, regardless of whether the coefficients are significant or not.

Table 2.12. Coefficients of Inflation Persistence and Full ERPT into CPI

Country	Inflation Persistence		Full ERPT into CPI	
	Pre ITF	Post ITF	Pre ITF	Post ITF
Indonesia	0.315	0.208	-0.362	-0.507
Korea	0.531	0.086	-0.089	-0.046
Philippines	0.606	0.425	-0.090	0.008
Thailand	0.559	0.213	-0.069	-0.024

From this summary, we can see that the inflation persistence in these countries declined after implementation of the ITF. Korea experienced the biggest fall, followed by Thailand, Philippines and Indonesia. For the ERPT into CPI, only Korea and Thailand demonstrated declining ERPT. Meanwhile, Indonesia and Philippines showed contrasting results. However, this summary ignores the significance of the coefficient of the ITF dummy. To confirm whether these coefficients are statistically significant, we perform a Wald test. In particular, we test if the restrictions of the coefficients of the ITF dummy are equal to zero. Below are the results of the Wald test:

Table 2.13. Wald Test Results

Country	Inflation Persistence	Full ERPT into CPI
	Wald test	Wald test
Indonesia	0.591	0.627
Korea	7.592 ***	2.940 *
Philippines	1.834	0.332
Thailand	28.385 ***	0.774

*, ***, *** statistically significant at ten percent, five percent, and one percent respectively

The Wald test results show that only Korea and Thailand experienced declining inflation persistence. The sum of the coefficients of the ITF dummy, related to the lag of CPI, is statistically different from zero at one percent level. For Indonesia and Philippines, these coefficients are insignificant. In the previous section we found that the inflation persistence of Indonesia and Philippines decreased after the Asian crisis, although this was less significant. However, based on the latest estimations, these changes are not attributable to the implementation of ITF. These estimations only confirm that implementing ITF in Korea and Thailand had a significant effect on their inflation persistence.

The Wald tests for the ERPT support the conclusion made in the previous section; that Korea experienced declining ERPT after the Asian crisis. The Wald test is significant at ten percent level. This result suggests that the declining ERPT is related to the ITF implementation. Meanwhile, other countries have the same ERPT into CPI before and after the ITF implementation.

One possible explanation of the difference results is the starting dates of the ITF implementation in these countries. Korea and Thailand implemented ITF earlier than the other countries. Logically, the longer the implementation, the higher the credibility gain is. This could contribute to the declining inflation persistence in these two countries and the declining ERPT in Korea.

2.7. Conclusions

In this chapter, we examine the inflation dynamics in selected Asian countries; namely inflation persistence and exchange rate pass through. The countries investigated are Hong Kong, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand. We use quarterly data from 1985Q1 to 2010Q1. As the objective is to confirm whether inflation dynamic changes after the Asian crisis, we divide the sample according to the Asian financial crisis period.

The estimation results confirm that most of the countries experienced a decline in terms of inflation mean and inflation persistence after the Asian crisis. In terms of ERPT, the estimation results are less clear. However, there is an interesting result that is worth noting. Amongst the countries under investigation, some ITF countries, such as Indonesia, Korea, and Philippines, experience declining ERPT; in particular its second ERPT. Even the coefficients after the crisis are insignificant. This finding could support the argument made by Taylor (2000) and Mishkin (2008); that a more stable monetary condition and well anchored inflation lead to a lower ERPT. In particular, ITF that is implemented in these countries, may have contributed to the changes.

To confirm this, we provide estimations to examine the role of ITF, given the occurrence of the inflation dynamic changes. The estimation results suggest that not all of these ITF countries experience changes in inflation persistence and ERPT into CPI, after the ITF's implementation. For the inflation persistence, this only happened in Korea and Thailand. Meanwhile, for the ERPT into CPI, it was only apparent in Korea. This may be due to the fact that ITF was implemented earlier in these two countries. This could generate more credibility. Given this result, it is too early to make generalised that ITF

exerts a consistently discernible influence on inflation dynamics across this group of Asian countries.

With regards to the estimation; in particular the estimation of the exchange rate pass through, we do not find cointegration for most of the estimations. Hence we end up with the measurement of the full or cumulative exchange rate pass through instead of the long run exchange rate pass through. One possible explanation for this is the number of observations. For future work, it may be useful to re-estimate the model with additional observations. Given this, we can also re-estimate and compare the results using the other cointegration approaches.

Appendix 2.1. Unit Root Test Pre and Post Crisis, and Full Sample

All of the series are in difference logarithm to make sure the series are not I(2).

Country	Consumer Price Index				Import Price Index			
	t-stat				t-stat			
	1985Q1-1997Q2		2000Q1-2010Q1		1985Q1-1997Q2		2000Q1-2010Q1	
Hong Kong	-2.689	*	-3.103	**	-3.923	***	-2.635	*
Indonesia	-6.544	***	-5.390	***	NA		-5.300	***
Korea	-6.037	*** ¹⁾	-6.166	*** ¹⁾	-5.392	***	-3.868	***
Malaysia	-5.739	***	-4.972	***	NA		NA	
Philippines	-3.081	**	-4.556	***	NA		NA	
Singapore	-3.124	**	-2.882	*	-4.423	***	-5.030	***
Taiwan	-6.634	***	-5.275	***	-4.220	***	-4.875	***
Thailand	-2.700	*	-4.165	***	-5.166	***	-4.690	***

*, **, *** statistically significant at ten percent, five percent, and one percent respectively

1) Korea's CPI before the crisis is I(2), hence we use GDP deflator for both before and after the crisis

Country	Exporting Country Price Index				Nominal Effective Exchange Rate			
	t-stat				t-stat			
	1985Q1-1997Q2		2000Q1-2010Q1		1985Q1-1997Q2		2000Q1-2010Q1	
Hong Kong	-8.044	***	-3.247	**	-5.733	***	-4.789	***
Indonesia	-3.971	***	-4.117	***	-5.809	*** ²⁾	-6.220	*** ²⁾
Korea	-5.050	***	-3.301	**	-4.414	***	-4.661	***
Malaysia	-4.473	***	-4.229	***	-6.037	*** ³⁾	-5.164	*** ³⁾
Philippines	-4.653	***	-4.059	***	-4.666	***	-4.806	***
Singapore	-8.598	***	-3.814	***	-4.043	***	-5.851	***
Taiwan	-4.583	*** ⁴⁾	-3.643	*** ⁴⁾	-4.232	*** ⁵⁾	-6.436	*** ⁵⁾
Thailand	-3.995	***	-3.638	***	-5.644	*** ⁶⁾	-4.419	*** ⁶⁾

*, **, *** statistically significant at ten percent, five percent, and one percent respectively

2) For Indonesia, there is no data for NEER before the crisis, hence we use nominal exchange rate (USD/local currency) for both subsamples

3) For Malaysia, NEER are I(2) according to the ADF test, hence we use nominal exchange rate (USD/local currency)

4) For the exporting country price index of Taiwan, we use CPI of the US since there is no relevant data available

5) For Taiwan, there is no data for NEER before the crisis, hence we use nominal exchange rate (USD/local currency)

6) For Thailand, there is no data for NEER before the crisis, hence we use nominal exchange rate (USD/local currency)

Unit root test for ITF estimations

Country	Consumer Price Index ¹⁾		Exporting Country Price Index		Nominal Effective Exchange Rate ²⁾	
	t-stat		t stat		t-stat	
	1985Q1-2010Q1		1985Q1-2010Q1		1985Q1-2010Q1	
Indonesia	-5.595	***	-7.697	***	-6.274	***
Korea	-8.012	***	-11.837	***	-8.160	***
Philippines	-5.242	***	-6.304	***	-6.915	***
Thailand	-6.006	***	-7.389	***	-6.639	***

*, **, *** statistically significant at ten percent, five percent, and one percent respectively

1) For Korea, it is GDP deflator to make it consistent with the ERPT section

2) For Indonesia and Thailand, it is nominal exchange rate in terms of USD

Appendix 2.2. The Mean of Inflation Pre and Post Crisis (QtQ)

Country	Manual structural break ²			Automatic structural break ³			Date of Break
	Pre Crisis	Post Crisis	difference ⁴	Pre Crisis	Post Crisis	difference ⁴	
Korea	0.014	0.008	0.006	0.014	0.007	0.007	1998q3
Singapore	0.455	0.370	0.085	0.463	0.291	0.172	1999q1
Malaysia	0.695	0.548	0.147	0.750	0.528	0.222	1999q1
Taiwan	0.662	0.226	0.436	0.707	0.223	0.484	1997q1
Thailand	1.088	0.638	0.450	1.191	0.559	0.632	1998q3
Philippines	2.081	1.195	0.886	2.109	1.187	0.922	1999q2
Indonesia	1.910	2.100	-0.190	2.894	1.954	0.940	1999q1
Hong Kong	1.915	0.050	1.865	1.854	-0.097	1.951	1999q4

1. We calculate the mean by averaging the QtQ inflation of each samples

2. The break is determined manually or arbitrarily using the period of crisis 1997:3 to 1999:4 as a result the pre crisis sample is 1985:1-1997:2 and the post crisis sample is 2000:1-2010:1

3. The break is based on the Andrews-Quandt test that refers to a specific quarter.

4. Positive means declining

Appendix 2.3. The Inflation Persistence of Pre and Post Crisis (QtQ)

Country	Method	Manual structural break ¹			Automatic structural break ²			Date of Break	
		Pre Crisis	Post Crisis	difference ³	Pre Crisis	Post Crisis	difference ³		
Hong Kong	AR(1) OLS	0.470	0.378	0.092	0.502	0.400	0.102	1998q3	*
	AR(1) Bootstrap	0.096	0.024	0.071	0.115	0.022	0.093		
Indonesia	AR(1) OLS	-0.050	0.116	-0.166	0.919	0.219	0.700	1998q4	*
	AR(1) Bootstrap	-0.015	-0.021	0.006	0.409	0.016	0.392		
Korea	AR(1) OLS	0.237	-0.077	0.314	0.251	0.021	0.229	1998q2	*
	AR(1) Bootstrap	-0.007	-0.022	0.015	-0.002	-0.028	0.026		
Malaysia	AR(1) OLS	0.0003	0.197	-0.196	0.080	0.189	-0.109	1999q2	
	AR(1) Bootstrap	-0.025	-0.007	-0.018	-0.020	-0.022	0.002		
Philippines	AR(1) OLS	0.369	0.299	0.070	0.368	0.295	0.074	1999q2	
	AR(1) Bootstrap	0.047	0.008	0.039	0.042	0.012	0.030		
Singapore	AR(1) OLS	0.451	0.511	-0.060	0.453	0.534	-0.081	1997q4	*
	AR(1) Bootstrap	0.088	0.113	-0.025	0.084	0.133	-0.049		
Taiwan	AR(1) OLS	0.024	-0.053	0.077	0.013	-0.102	0.116	1996q4	
	AR(1) Bootstrap	-0.021	-0.026	0.006	-0.012	-0.025	0.013		
Thailand	AR(1) OLS	0.079	0.188	-0.110	0.253	0.207	0.046	1998q3	
	AR(1) Bootstrap	-0.021	-0.010	-0.011	-0.007	-0.003	-0.004		

1. The break is determined manually or arbitrarily using the period of crisis 1997:3 to 1999:4 as a result the pre crisis sample is 1985:1-1997:2 and the post crisis sample is 2000:1-2010:1
 2. The break is based on Andrews-Quandt test that refer to a specific quarter.
 3. Positive means declining
- * the break is statistically significant at ten percent based on Andrew Ploberger critical value

Country	Method	Manual structural break ¹			Automatic structural break ²			Date of Break
		Pre Crisis	Post Crisis	difference ³	Pre Crisis	Post Crisis	difference ³	
Hong Kong	AR(2) OLS	0.691	0.588	0.103	0.702	0.556	0.146	1998q1
	AR(2) Bootstrap	0.403	0.251	0.152	0.413	0.209	0.204	
Indonesia	AR(2) OLS	-0.320	0.052	0.268	0.983	0.231	0.752	1998q4
	AR(2) Bootstrap	-0.071	-0.082	-0.011	0.423	0.027	0.396	
Korea	AR(2) OLS	0.144	-0.313	-0.170	0.127	-0.184	-0.057	1998q2
	AR(2) Bootstrap	-0.102	-0.069	0.033	-0.100	-0.101	-0.001	
Malaysia	AR(2) OLS	0.002	-0.011	-0.009	0.062	-0.011	0.050	1998q3
	AR(2) Bootstrap	-0.064	-0.145	-0.081	-0.062	-0.139	-0.077	
Philippines	AR(2) OLS	0.388	0.176	0.212	0.388	0.183	0.206	1999q2
	AR(2) Bootstrap	0.079	-0.079	-0.001	0.075	-0.094	-0.019	
Singapore	AR(2) OLS	0.627	0.482	0.145	0.631	0.496	0.135	1997q4
	AR(2) Bootstrap	0.315	0.092	0.224	0.309	0.114	0.196	
Taiwan	AR(2) OLS	-0.218	-0.489	-0.272	-0.220	-0.544	-0.324	1997q1
	AR(2) Bootstrap	-0.088	-0.133	-0.045	-0.091	-0.085	0.006	
Thailand	AR(2) OLS	0.185	-0.123	0.062	0.379	-0.076	0.303	1998q3 *
	AR(2) Bootstrap	-0.052	-0.179	-0.127	0.016	-0.158	-0.142	

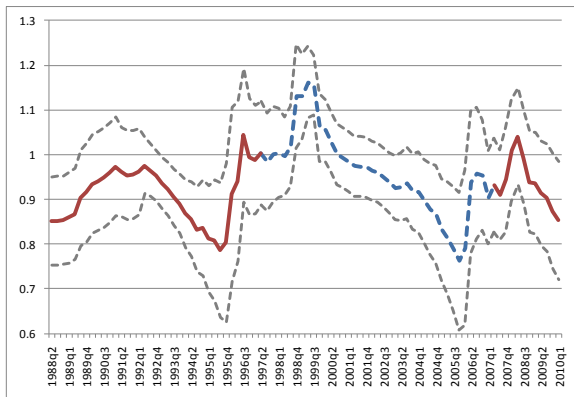
1. The break is determined manually or arbitrarily using the period of crisis 1997:3 to 1999:4 as a result the pre crisis sample is 1985:1-1997:2 and the post crisis sample is 2000:1-2010:1
 2. The break is based on Andrews-Quandt test that refer to a specific quarter.
 3. Positive means declining
- * the break is statistically significant at ten percent based on Andrew Ploberger critical value

Country	Method	Manual structural break ¹			Automatic structural break ²			Date of Break
		Pre Crisis	Post Crisis	difference ³	Pre Crisis	Post Crisis	difference ³	
Hong Kong	AR(p)	0.789	0.588	0.201	0.829	0.400	0.428	1998q3 *
Indonesia	AR(p)	-0.320	0.116	-0.437	0.919	0.219	0.700	1998q4 *
Korea	AR(p)	0.594	-0.077	0.671	0.251	0.021	0.229	1998q2 *
Malaysia	AR(p)	0.000	0.197	-0.196	0.080	0.189	-0.109	1999q2
Philippines	AR(p)	0.338	0.299	0.039	0.215	0.295	-0.080	1999q2
Singapore	AR(p)	0.627	0.511	0.116	0.631	0.534	0.097	1997q4 *
Taiwan	AR(p)	0.024	-0.489	0.513	0.013	-0.560	0.573	1996q4
Thailand	AR(p)	0.079	-0.123	0.202	0.253	-0.076	0.328	1998q3

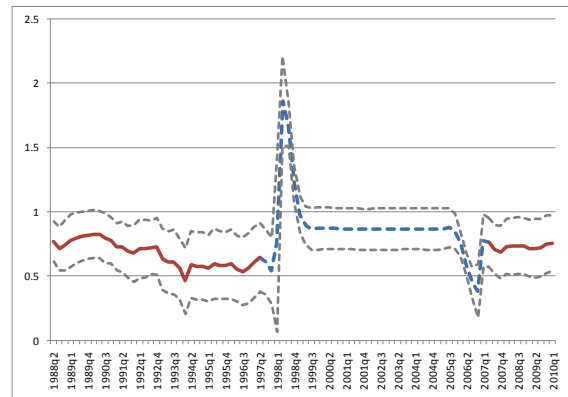
1. The break is determined manually or arbitrarily using the period of crisis 1997:3 to 1999:4 as a result the pre crisis sample is 1985:1-1997:2 and the post crisis sample is 2000:1-2010:1
 2. The break is based on Andrews-Quandt test that refer to a specific quarter.
 3. Positive means declining
- * the break is statistically significant at ten percent based on Andrew Ploberger critical value

Appendix 2.4. Rolling Regression of Inflation Persistence using AR(1) YoY

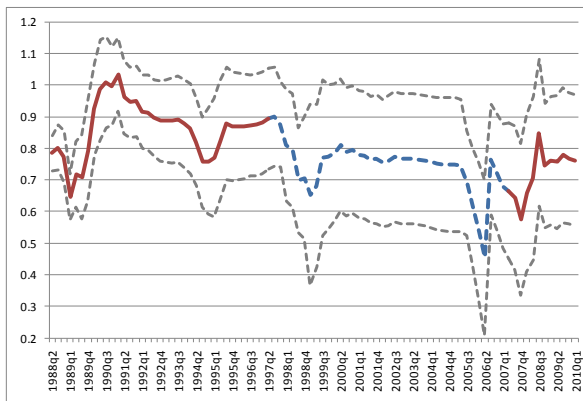
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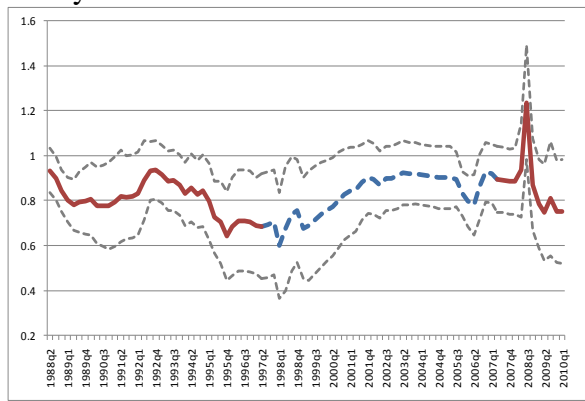
Indonesia



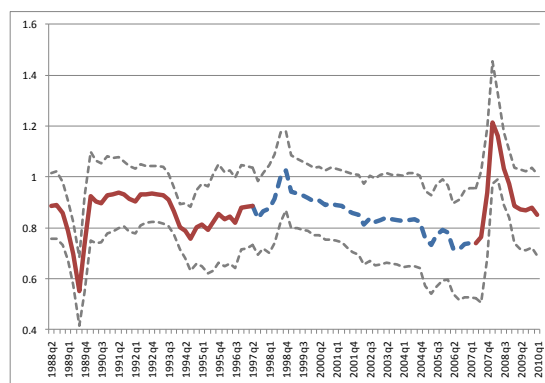
Korea



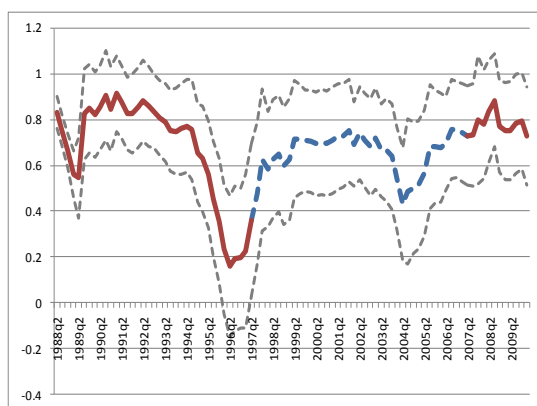
Malaysia



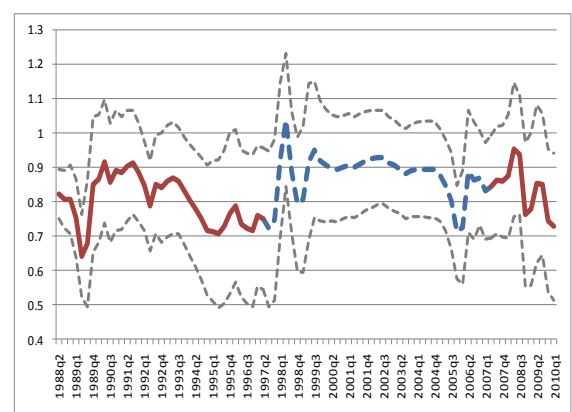
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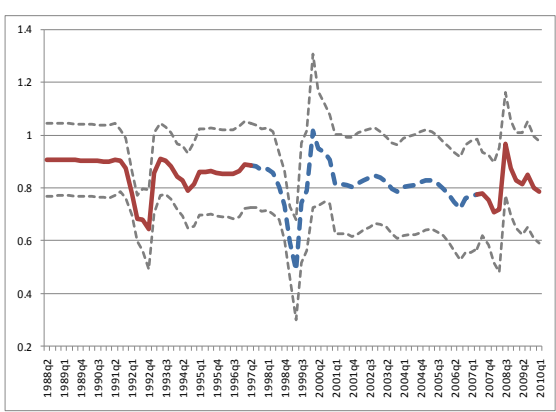
Taiwan



Thailand

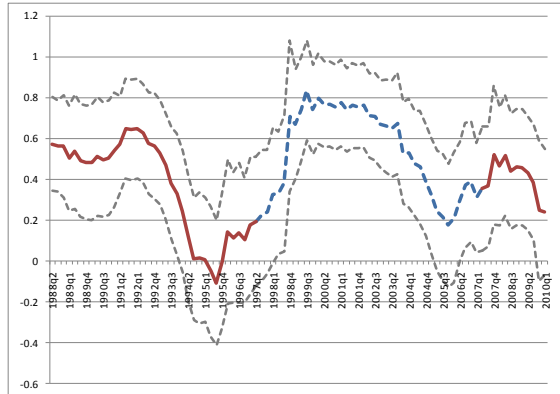


Philippines

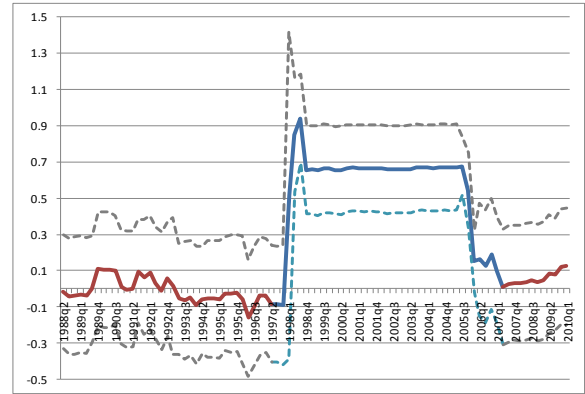


Appendix 2.5. Rolling Regression of Inflation Persistence using AR(1) QtQ

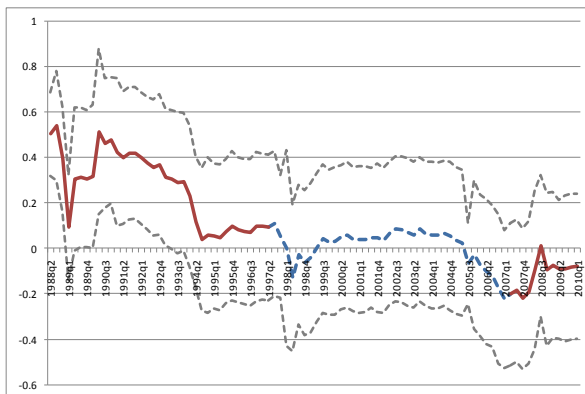
Hong Kong



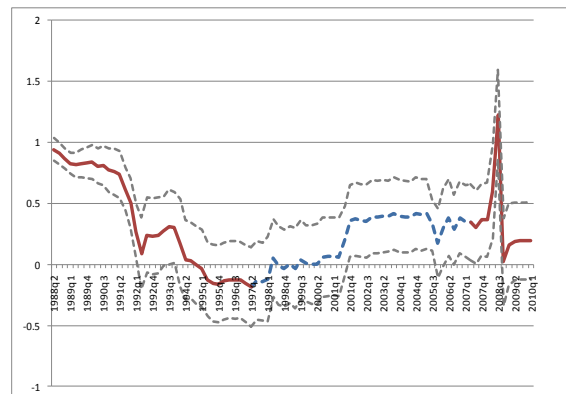
Indonesia



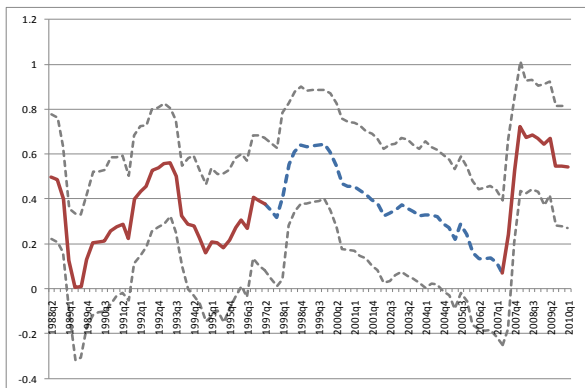
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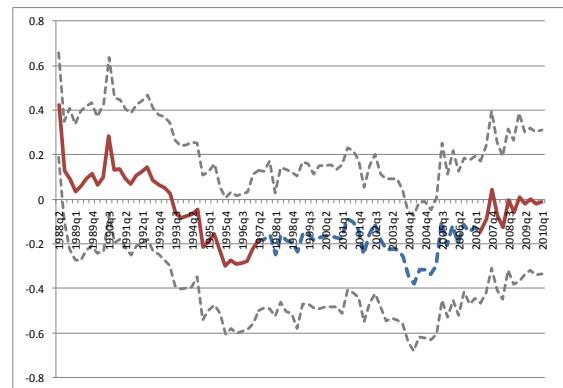
Malaysia



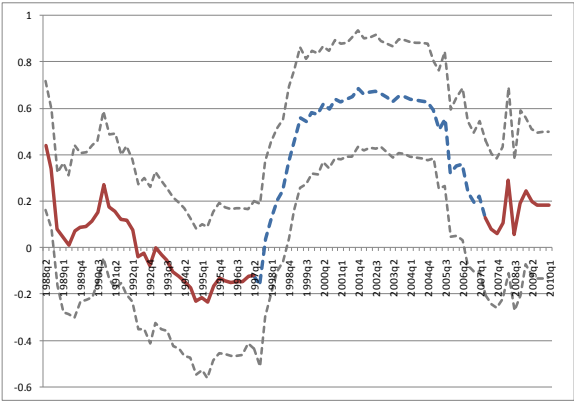
Singapore



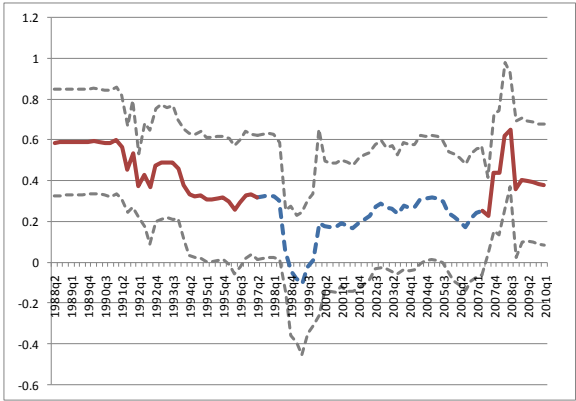
Taiwan



Thailand



Philippines



Appendix 2.6. Estimation Results of ERPT Pre and Post Crisis

<i>Hong Kong</i>	Exchange Rate Pass Through			
	Into Import Price		Into CPI	
	Pre Crisis	Post Crisis	Pre Crisis	Post Crisis
	<i>ARDL(1,0,0)</i>	<i>ARDL(1,0,0)</i>	<i>ARDL(2,0,0)</i>	<i>ARDL(3,0,0)</i>
DlogP _t ^m or DlogP _t				
C	-0.001 (0.001)	-0.008 (0.007)	0.003 (0.002)	-0.01 (0.009)
DlogP _{t-1} ^m or DlogP _{t-1}	0.439 *** (0.101)	0.642 ** (0.085)	0.45 ** (0.150)	0.269 * (0.135)
DlogP _{t-2} ^m or DlogP _{t-2}			0.327 ** (0.138)	-0.112 (0.151)
DlogP _{t-3} ^m or DlogP _{t-3}				0.456 *** (0.133)
DlogE _t	-0.13 *** (0.033)	-0.096 ** (0.045)	-0.021 (0.020)	0.02 (0.058)
DlogP _t *	0.316 *** (0.080)	0.33 *** (0.081)	0.101 ** (0.048)	0.424 *** (0.104)
Wald test (Ho: Coef E=0)	15.885 *** [0.000]	4.458 ** [0.035]	1.137 [0.286]	0.118 [0.731]
Adj R ²	0.526	0.783	0.605	0.585
F test	1.842	1.341	1.557	1.698
Serial Corellation	[0.142]	[0.275]	[0.207]	[0.176]
F test	1.834	0.002	0.869	3.545
Heteroskedasticity	[0.183]	[0.962]	[0.356]	[0.067]
Ramsey Reset	1.834 [0.183]	0.282 [0.599]	0.059 [0.809]	0.3 [0.587]
Normality	0.007 [0.302]	0.178 [0.915]	1.944 [0.378]	0.584 [0.747]

*, **, *** statistically significant at 10%, 5%, and 1% respectively

Values in parentheses () are standard error and the value in bracket [] are the probability

<i>Indonesia</i>		Exchange Rate Pass Through			
DlogP _t ^m or DlogP _t	Into Import Price ¹		Into CPI		
	Post Crisis		Pre Crisis	Post Crisis	
	<i>ARDL(1,0,0)</i>		<i>ARDL(0,0,0)</i>	<i>ARDL(0,0,0)</i>	
C	0.016		0.018 ***	0.019 ***	
	(0.005)		(0.179)	(0.003)	
DlogP _{t-1} ^m or DlogP _{t-1}	-0.356 **				
	(0.132)				
DlogE _t ²	-0.287 ***		-0.067 **	-0.021	
	(0.080)		(0.030)	(0.041)	
DlogP _t *	2.111 ***		0.228	0.120	
	(0.298)		(0.179)	(0.126)	
Wald test	12.965 ***		5.160 **	0.393	
(Ho: Coef E=0)	[0.000]		[0.023]	[0.531]	
Adj R ²	0.589		0.082	0.024	
F test	0.159		0.91	0.369	
Serial Corellation	[0.957]		[0.468]	[0.829]	
F test	0.029		0.664	0.068	
Heteroskedasticity	[0.865]		[0.420]	[0.796]	
Ramsey Reset	0.537		0.475	0.164	
	[0.469]		[0.495]	[0.688]	
Normality	0.179		19.543	303.7	
	[0.914]		[0.000]	[0.000]	

1. It is only for post crisis period given the limited data available for pre crisis.

2. Exchange rate in USD/domestic currency given the availability of data

* statistically significant at ten percent, ** statistically significant at five percent

*** statistically significant at one percent

Values in parentheses () are standard error and the value in bracket [] are the probability

<i>Korea</i>	Exchange Rate Pass Through					
	Into Import Price			Into CPI ¹		
	Pre Crisis		Post Crisis	Pre Crisis		Post Crisis
	<i>ARDL(0,2,1)</i>		<i>ARDL(0,0,0)</i>	<i>ARDL(0,0,0)</i>		<i>ARDL(0,0,0)</i>
DlogP _t ^m or DlogP _t	0.003		-0.004	0.016		0.012 **
	(0.003)		(0.003)	(0.001)		(0.003)
DlogP _{t-1} ^m or DlogP _{t-1}						-0.085
						(0.163)
DlogP _{t-2} ^m or DlogP _{t-2}						-0.148
						(0.148)
DlogP _{t-3} ^m or DlogP _{t-3}						-0.358 **
						(0.149)
DlogP _{t-4} ^m or DlogP _{t-4}						-0.211
						(-1.328)
DlogE _t	-0.252 **		-0.589 ***	-0.129 ***		-0.015
	(0.108)		(0.063)	(0.047)		(0.003)
DlogE _{t-1}	-0.225 **					
	(0.110)					
DlogP _t [*]	2.914 ***		2.938 ***	0.239		-0.006
	(0.488)		(0.252)	(0.207)		(0.039)
DlogP _{t-1} [*]	-1.118 **					
	(0.464)					
DlogP _{t-2} [*]	-1.303 ***					
	(0.452)					
Wald test	13.364 ***		87.735 ***	7.513 ***		0.138
(Ho: Coef E=0)	[0.000] **		[0.000]	[0.006]		[0.711]
Adj R ²	0.531		0.809	0.12		0.052
F test	0.708		0.868	0.378		1.176
Serial Corellation	(0.592)		[0.493]	[0.823]		[0.341]
F test	2.529		0.729	0.011		2.102
Heteroskedasticity	(0.119)		[0.399]	[0.919]		[0.155]
Ramsey Reset	0.102		0.532	0.628		3.199
	(0.751)		[0.470]	[0.433]		[0.083]
Normality	0.645		0.366	1.625		11.015
	(0.059)		[0.833]	[0.444]		[0.004]

1. We use GDP deflator since CPI is I(2)

* statistically significant at ten percent, ** statistically significant at five percent

*** statistically significant at one percent

Values in parentheses () are standard error and the value in bracket [] are the probability

<i>Malaysia</i>	Exchange Rate Pass Through	
	Into CPI ¹	
	Pre Crisis	Post Crisis
DlogP _t	ARDL(1,0,0)	ARDL(1,0,0)
C	0.007 *** (0.007)	0.002 * (0.001)
DlogP _{t-1}		0.357 (0.113)
DlogE _t ²	-0.027 (0.035)	-0.119 *** (0.059)
DlogE _{t-1}	0.088 ** (0.033)	
DlogP _t *	-0.008 (0.077)	0.349 (0.051)
Wald test (Ho: Coef E=0)	1.83 [0.176]	4.01 *** [0.045]
Adj R ²	0.089	0.654
F test	0.859	0.553
Serial Corellation	[0.497]	[0.698]
F test	1.125	31.283
Heteroskedasticity	[0.295]	[0.000]
Ramsey Reset	0.061 [0.807]	11.328 [0.002]
Normality	0.172 [0.917]	23.604 [0.000]

1. No ERPT into Import Price given the limited availability data

2. Exchange rate in USD/domestic currency given the data in difference log is non-stationary

* statistically significant at ten percent, ** statistically significant at five percent

*** statistically significant at one percent

Values in parentheses () are standard error and the value in bracket [] are the probability

<i>Philippines</i>	Exchange Rate Pass Through			
	Into CPI ¹			
	Pre Crisis		Post Crisis	
DlogP _t	<i>ARDL(1,1,1)</i>		<i>ARDL(1,0,0)</i>	
C	0.008	***	0.007	***
	(0.002)		(0.002)	
DlogP _{t-1}	0.535	***	0.296	***
	(0.098)		(0.137)	
DlogE _t	-0.006		-0.04	
	(0.036)		(0.054)	
DlogE _{t-1}	-0.069	**		
	(0.034)			
DlogP _t *	0.343	*	0.309	***
	(0.195)		(0.088)	
DlogP _{t-1} *	0.615	***		
	(0.183)			
DlogP _{t-2} *	0.458	**		
	(2.175)			
Wald test	3.988	**	0.544	
(Ho: Coef E=0)	[0.046]		[0.461]	
Adj R ²	0.635		0.264	
F test	1.482		0.593	
Serial Corellation	[0.229]		[0.670]	
F test	1.317		0.010	
Heteroskedasticity	[0.257]		[0.976]	
Ramsey Reset	8.244		5.121	
	[0.007]		[0.030]	
Normality	0.795		462.434	
	[0.672]		[0.000]	

1. There is no ERPT into import price given the availability of data

* statistically significant at ten percent, ** statistically significant at five percent

*** statistically significant at one percent

Values in parentheses () are standard error and the value in bracket [] are the probability

Singapore		Exchange Rate Pass Through					
DlogP _t ^m or DlogP _t	Into Import Price				Into CPI		
	Pre Crisis		Post Crisis		Pre Crisis		Post Crisis
	ARDL(1,1,0)		ARDL(1,0,2)		ARDL(1,0,		ARDL(1,0,0)
C					0.002	***	0.008
					(0.006)		(0.008
DlogP _{t-1} ^m or DlogP _{t-1}					0.418	***	0.547
					(0.103)		(0.127
DlogE _t	-0.261	***	-0.037		0.055		-0.087
	(0.079)		(0.083		(0.026)		(0.082
DlogP _t [*]	2.42	***	1.01	***	0.176	***	0.136
	(0.271)		(0.088		(0.057)		(0.045
ECM _{t-1}	-0.554	***	-0.203	***			
	(0.079)		(0.053				
$ECM_{t-1} = logP_{t-1} - (C + a_1 logE_{t-1} + a_2 logP_{t-1}^*)$							
C	5.358	***	4.803	***			
	(0.244)		(1.413				
logE _{t-1}	-0.47	***	-0.18				
	(0.099)		(0.400				
logP _{t-1} [*]	0.284		0.125				
	(0.244)		(0.134				
Wald test	NA		NA		4.731	**	1.125
(Ho: Coef E=0)					[0.03		[0.289
Adj R ²	0.713		0.79		0.534		0.488
F test	0.358		1.426		0.89		1.774
Serial Corellation	[0.837]		[0.248		[0.47		[0.158
F test	1.447		1.651		7.335		1.597
Heteroskedasticity	[0.235]		[0.206		[0.01		[0.214
Ramsey Reset	0.003		1.335		0.098		3.509
	[0.954]		[0.256		[0.75		[0.069
Normality	2.19		2.816		3.039		3.182
	[0.335]		[0.245		[0.21		[0.204

* statistically significant at ten percent, ** statistically significant at five percent

*** statistically significant at one percent

Values in parentheses () are standard error and the value in bracket [] are the probability

<i>Taiwan</i>	Exchange Rate Pass Through					
	Into Import Price ¹			Into CPI ¹		
	Pre Crisis		Post Crisis	Pre Crisis		Post Crisis
	<i>ARDL(0,1,0)</i>		<i>ARDL(0,0,0)</i>	<i>ARDL(0,0,0)</i>		<i>ARDL(0,0,1)</i>
DlogP _t ^m or DlogP _t						
C	0.002		0.003	0.008 ***		0.003 ***
	(0.003)		(0.003)	(0.001)		(0.001)
DlogE _t ²	-0.544 ***		0.013	-0.063		0.071 *
	(0.125)		(0.127)	(0.044)		(0.037)
DlogE _{t-1}						0.094 ***
						(0.034)
DlogP _t [*]	0.185 ***		0.292 ***	-0.003		0.002
	(0.064)		(0.043)	(0.021)		(0.012)
DlogP _{t-1} [*]	0.164 ***					
	(0.062)					
Wald test	18.914 ***		0.011	2.063		10.083 ***
(Ho: Coef E=0)	[0.000]		[0.915]	[0.151]		[0.001]
Adj R ²	0.416		0.57	0.01		0.193
F test	0.251		1.014	0.219		1.31
Serial Corellation	[0.907]		[0.414]	[0.926]		[0.287]
F test	0.017		0.198	0.133		0.105
Heteroskedasticity	[0.895]		[0.659]	[0.717]		[0.747]
Ramsey Reset	0.284		3.973	0.401		3.051
	[0.597]		[0.054]	[0.530]		[0.139]
Normality	7.751		0.807	0.281		27.369
	[0.021]		[0.668]	[0.869]		[0.000]

1. Foreign price is proxied by CPI of the US

2. Exchange rate in USD/domestic currency given the availability of data

* statistically significant at ten percent, ** statistically significant at five percent

*** statistically significant at one percent

Values in parentheses () are standard error and the value in bracket [] are the probability

<i>Thailand</i>	Exchange Rate Pass Through							
	Into Import Price				Into CPI			
	Pre Crisis		Post Crisis		Pre Crisis		Post Crisis	
	<i>ARDL(0,0,0)</i>		<i>ARDL(2,0,2)</i>		<i>ARDL(2,1,0)</i>		<i>ARDL(0,0,0)</i>	
DlogP _t ^m or DlogP _t	0.013	***	0.008	***	0.008	***	0.004	***
	(0.003)		(0.002)		(0.002)		(0.001)	
DlogP _{t-1} ^m or DlogP _{t-1}			0.088		-0.074			
			(0.104)		(0.134)			
DlogP _{t-2} ^m or DlogP _{t-2}			-0.278	***	0.386	***		
			(0.102)		(0.127)			
DlogE _t ¹	-0.069		-0.884	***	0.033		-0.019	
	(0.32)		(0.070)		(0.083)		(0.027)	
DlogE _{t-1}			0.113					
			(0.106)					
DlogE _{t-2}			-0.43	***				
			(0.102)					
DlogP _t [*]	1.992	***	1.281	***	0.041		0.539	***
	(0.364)		(0.149)		(0.099)		(0.056)	
DlogP _{t-1} [*]					0.271	***		
					(0.098)			
Wald test	0.046		47.119	***	0.162		0.484	
(Ho: Coef E=0)	[0.830]		[0.000]		[0.687]		[0.487]	
Adj R ²	0.39		0.854		0.303		0.701	
F test	2.813		1.335		0.611		0.283	
Serial Corellation	[0.039]		[0.280]		[0.658]		[0.887]	
F test	0.813		0.028		6.377		0.381	
Heteroskedasticity	[0.372]		[0.868]		[0.015]		[0.541]	
Ramsey Reset	5.766		0.071		1.686		0.004	
	[0.021]		[0.792]		[0.202]		[0.947]	
Normality	4.598		5.215		0.454		25.868	
	[0.100]		[0.074]		[0.797]		[0.000]	

1. Exchange rate in USD/domestic currency given the availability of data

* statistically significant at ten percent, ** statistically significant at five percent

*** statistically significant at one percent

Values in parentheses () are standard error and the value in bracket [] are the probability

Appendix 2.7. Estimation Results of ITF's Role for ITF countries

DlogP _t	Indonesia		Korea		Philippines		Thailand	
C	0.010	***	0.006	***	0.006	***	0.005	***
	<i>0.002</i>		<i>0.002</i>		<i>0.002</i>		<i>0.001</i>	
D _{crisis}	0.003		-0.004	**	-0.001		-0.003	
	<i>0.006</i>		<i>0.002</i>		<i>0.004</i>		<i>0.002</i>	
DlogP _{t-1}	0.315	***	0.275	***	0.606	***	0.194	*
	<i>0.108</i>		<i>0.090</i>		<i>0.082</i>		<i>0.110</i>	
IT*DlogP _{t-1}	-0.107		-0.348	**	-0.181		-0.345	**
	<i>0.139</i>		<i>0.192</i>		<i>0.134</i>		<i>0.159</i>	
DlogP _{t-2}			0.151	*			0.365	***
			<i>0.092</i>				<i>0.109</i>	
IT*DlogP _{t-2}			-0.192				-0.299	**
			<i>0.199</i>				<i>0.144</i>	
DlogP _{t-3}			0.105					
			<i>0.091</i>					
IT*logP _{t-3}			0.095					
			<i>0.185</i>					
DlogE _t	-0.106	***	-0.080	***	-0.035		-0.056	***
	<i>0.015</i>		<i>0.012</i>		<i>0.029</i>		<i>0.015</i>	
IT*DlogE _t	-0.109	***	0.038	*	0.040		0.030	
	<i>0.087</i>		<i>0.022</i>		<i>0.069</i>		<i>0.034</i>	
DlogE _{t-1}	-0.064	***						
	<i>0.015</i>							
IT*DlogE _{t-1}	0.048							
	<i>0.067</i>							
DlogE _{t-2}	-0.078	***						
	<i>0.018</i>							
IT*DlogE _{t-2}	-0.042							
	<i>0.074</i>							
DlogE _{t-3}	-0.028							
	<i>0.018</i>							
IT*DlogE _{t-3}	-0.022							
	<i>0.067</i>							
DlogP _t ^f	-0.024		-0.013		0.226		0.076	
	<i>0.108</i>		<i>0.136</i>		<i>0.138</i>		<i>0.077</i>	
IT*DlogP _t ^f	0.418	***	0.217	***	0.040		0.517	***
	<i>0.204</i>		<i>0.086</i>		<i>0.069</i>		<i>0.034</i>	
Adj R ²	0.795		0.497		0.386		0.573	

*, **, *** statistically significant at 10%, 5%, and 1% respectively

Values in italic letter are standard error of the coefficients

Chapter 3

The Pass Through Of World Commodity Price Shocks

3.1. Background and Motivation

The first decade of the 2000s witnessed sharp increases in world commodity prices. The average oil price benchmark of West Texas Intermediate (WTI), UK Brent, and Dubai reached more than USD117/bbl in the second quarter of 2008, or more than five hundred percent higher than its average in the 1990s. Indices for non-fuel commodity prices, especially for food prices, also increased greatly. The volatility of these two price indices also rose. The movement of the two is similar, partly because in general energy prices influence the cost of fertilizer, which represents a key input into food production.

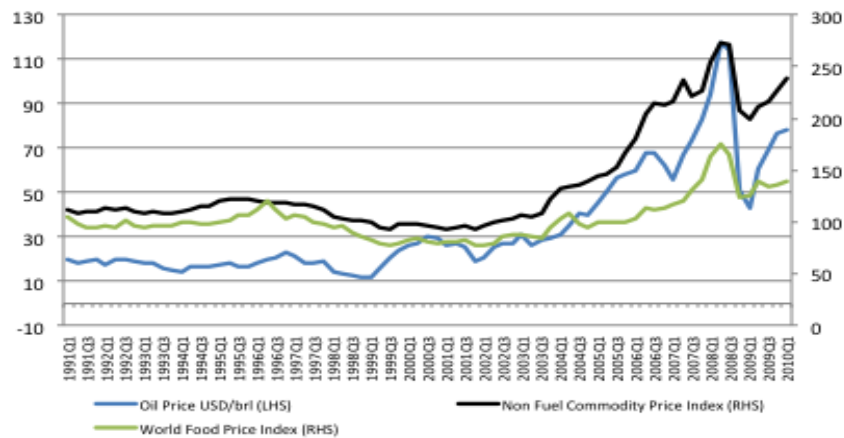
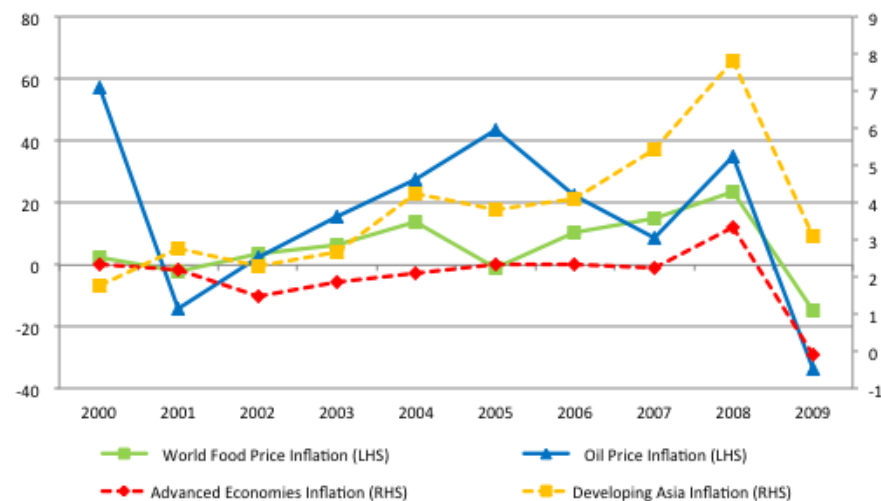


Figure 3.1. World Commodity Price Indices of the IMF

Kilian (2008) identifies three main sources of the oil price shock. These are: (i) the increase in the demand for energy; (ii) supply disruption and (iii) a precautionary demand shock specific to oil. These also explain the increase in world commodity prices in general. The growth acceleration in emerging countries has catalysed demand for commodities, since their growth is relatively more commodity-intensive than in developed countries. In addition, following two decades of low commodity prices, there was low investment in this

sector and the growth of supply was, as a result, also very modest. This combination contributes to the sharp spike in commodity prices. There is also a view that the recent increase is the result of investors' speculation. On the collapse of financial markets, commodities become an alternative asset, supported by the financialisation of commodity markets. However, this view is still unsettled. Krugman (2008) disagreed with this argument since it was unsupported by fundamental supply and demand. However, a year later he supported it, given that the oil inventory was bulging.



Source: IMF

Figure 3.2. World Inflation & Commodity Inflation (YoY)

Figure 3.2 demonstrates that, along with the increase in global commodity inflation, global inflation also increases. Inflation rates in advanced economies were relatively steady, at around two percent, from 2000, except in 2008 when there was a simultaneous sharp increase in oil and food commodity inflation. In contrast, inflation in developing Asia started to rise gradually from 2000. Its movement is in tandem, not only with world oil inflation, but also with world food inflation. Take for example the case in 2005; when oil inflation increased, inflation in advanced economies also slightly increased. However, inflation in developing Asia decreased, in line with world food inflation at the time.

Generally, emerging and developing economies are more vulnerable to an increase in world commodity prices than developed countries. The main reason for this is that these countries have a larger share of world commodities in their consumption. Furthermore, these countries are thought to have less credible monetary policies than any developed countries (IMF, 2008). Another reason is price control, in particular that on fuel prices, which was implemented in some of these countries. This policy means that the world price increases have not been fully passed through to domestic prices. This creates an uncertainty which comes from the possibility of a sharp increase in inflation if any subsidy related to the price control is reduced.

Governments' responses in mitigating the impact of world price increases depend on the characteristics of the individual country. For net exporters, increased taxes and some restrictions on exports are put in place to switch production towards meeting domestic consumption needs. For net importers, the policies involve relaxation of import restrictions and tariff rate reductions. Some governments increase subsidies when facing this situation.

From a monetary policy perspective, monetary authorities also respond to this challenge. Ideally, the role of the monetary authority is to maintain the medium-long term inflation path to facilitate sustainable economic growth. It would probably ignore world commodity shocks if these shocks are assumed to be transitory, or do not change the medium term inflation path. If the monetary authority tries to keep the inflation rate close to its target in the short term, this can lead to a large output loss. In practical terms, the monetary authority reacts whenever there is a second round pass through from world commodity shocks on the domestic inflation rate. However, to identify whether the shocks are transitory or permanent, or whether they create a second round effect, is a challenge. This is because there are many possible reasons for the movement in commodity prices. It

might be white noise, in which case their expected future values are unaffected. Or it might be following a random walk, so all expected future values rise in line. Alternatively, it might display a new, higher trend, or it might be anything between these three possibilities.

Against this backdrop, this chapter attempts to contribute to the discussion by answering the following questions:

1. Which commodity prices have exercised the greatest influence upon domestic inflation recently?
2. Do they generate a second pass through effect?

World commodity prices in this chapter refer to both world oil and world food prices. By placing the food price at the centre of the analysis, this chapter attempts to add to the knowledge, since up to now most of the literature has been concerned solely with oil price shock. The importance of food prices is stressed in some literature; for instance, Catao and Chang (2010) and Walsh (2011).

There are two main avenues of research associated with the impact of world commodity price shocks on macroeconomic variables. The first attempts to quantify the impact. The second avenue is to analyse its impact, to evaluate the policies conducted when facing sharp world commodity price rises?, and to find optimal policies. Given the research questions above, the research in this chapter belongs to the first category.

The various countries under investigation are the same as in the previous chapter: Hong Kong, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand. The close relationship between world commodity prices, especially food prices, and domestic prices in some of these countries is one of the considerations for their selection. Besides having a relatively high ratio of food consumption, some of them are also main producer countries, as well as main importer countries. For instance, Thailand is one of the

main producers of rice in the world and Philippines is the main importer of rice in the world (ADB, 2008). We can divide these countries into two groups: four Association of South East Asian Nation (ASEAN4) countries and four Newly Industrialized Economies (NIE4). ASEAN4 includes Indonesia, Malaysia, Philippines and Thailand. NIE4 includes Hong Kong, Korea, Singapore and Taiwan. The division is based on the different levels of economic development of the two groups. The former are classified as developing countries and the latter are more developed ones. Their dependence on world commodities is statistically different. This will provide a comparative study between the two groups of countries in the region.

The period follows the Asian financial crisis in the 2000s, since we want to see the effects of the recent development of world commodity prices. The characteristic shock of world commodity prices during this period is different from that of the 1990s. In this period, particularly in 2008, the key driver of the shock was the increase in aggregate demand, especially from emerging economies. Kilian (2006) emphasizes this, in particular for oil prices. Yet there were also major food price shocks during this period.

The structure of the remainder of this chapter is as follows. The next section reviews the relevant literature. Section 3.3 describes the methodology and data employed in this chapter. Section 3.4 explains the estimation results and section 3.5 is the conclusion.

3.2. Literature Review

The impact of the price of oil on economic variables became a highly topical subject for research when global recession occurred following the oil shock in the 1970s. Most of the economic research focuses on the effect of the oil price shock, not only on the inflation that ensued, but also much more on the economic output. Hamilton (1983) perhaps provides the first important research on this topic. His research is based on the

correlation found between the crude oil price shock and the output downturn in the US in 1974-1975. Based on this, three hypotheses are tested. These are that (1) the correlation simply represents a historical coincidence, (2) there is a third factor behind the correlation, and (3) there is a causal effect between the shock and the recession. He employs a system of equations that involves six variables: real GNP, unemployment, business income, wages, import prices and M1, and employs the Granger causality tests between the oil price and these variables.

Results suggest that oil price increases tend to be followed by a fall in real GNP. He cannot find any other macroeconomic variables that might act as causes of the recession. Moreover, he investigates whether some macroeconomic variables exert a causal effect on oil prices, but is unable to find any evidence for this. He argues that if the correlation between the oil price and output is not just a historical coincidence, then there should be a relationship between the two. However, he recognizes that an oil price increase is not both a necessary and a sufficient condition for the recession in the US. In other words, the correlation between them should not be viewed as a structural relation.

Immediately following Hamilton's research, a large number of researchers supported the notion of a negative relationship between the oil price and aggregate output. Take, for example, Burbidge and Harrison (1984), who study the impact of oil price shocks in Canada, Japan, West Germany, the US and in the UK. They employ a Vector Auto Regressive (VAR) model and use data from 1961 to 1982. They find that oil price shock increases wages and prices in all of the countries under investigation. Meanwhile, for output, they reveal a substantial decline in industrial production only in the US and Japan following the rise of the oil price. Mork et al. (1994) show that in addition to the US, the UK and West Germany also suffered an economic downturn after the oil price shock of

1973-1974. Rotemberg and Woodford (1996) quantify the effect of oil prices in terms of elasticity. They find that a one percent rise in the oil price is accompanied by a reduction of output by 0.25 percent after five to seven quarters in the US.

This relationship is valid up to 1980. But recent research highlights a weaker relationship. Historically, high oil prices were not accompanied by evidence of an economic downturn until 2008. For instance, Darrat, Gilley and Meyer (1996), and Hooker (1996), who use a VAR model and data up to 1990, show that oil prices no longer have an impact on output. On the other hand, the view that monetary policy has a more important role on output becomes more acceptable. Bernanke, Gertler and Watson (1997), who also use a VAR model, argue that the recession in 1974-1975 cannot be explained by the oil price shock. More important is the fact that a general commodity price shock encourages the monetary authorities to increase their policy interest rates. Barsky and Kilian (2004) also share the same view. However, the policy rate continues to rise, failing to match the actual rate of the inflation. If disinflationary pressure depends on an excessive rise in the rate of interest, policies became less expansionary, but not necessarily contractionary. Hamilton and Herrera (2004) also comment that monetary policy alone cannot be used to eliminate the consequence of oil price shock, as suggested by Bernanke, Gertler and Watson (1997). They question whether the Federal Reserve has the power to mitigate the contractionary effect of the shock. Another objection is that the lag length used in the Bernanke, Gertler and Watson (1997) model is so short that it cannot capture the effect of the oil price shock completely.

Blanchard and Gali (2007) provide one of the most comprehensive explanations of the effect of oil price shock across given periods. They do not only investigate the different effects of oil prices across given periods on a set of industrialised countries, but also on

output and inflation. In addition to this, they use various methodologies, ranging from a structural VAR to a theoretical model. In their structural VAR model for each country, they separate the analysis into pre-1983Q4 and post-1984Q1 by assuming a discrete break at around this point. Using the impulse responses they demonstrate that the effect of oil price shock on CPI inflation and GDP becomes weaker in the second subsample.

To confirm the result they perform bivariate rolling regressions without a break so that the changes of the effect may be displayed gradually over time. Price variables such as CPI inflation, wage inflation and GDP deflator do respond, particularly in the late 1970s. On the other hand, the sensitivity of output and employment changes dramatically, decreasing over time, and even becoming slightly positive thereafter.

Blanchard and Gali (2007) also construct a theoretical model to explain the change in the effect. The model consists of two sectors: households and firms. Oil is an input in both a firm's production and a household's consumption. Using the simulation of this model, they demonstrate that the changes of the oil price effect are due to three factors: an increase in real wage rigidities; increased credibility in monetary policy and simply the declining proportion of oil in household consumption and in firm production.

Regarding the policies taken when facing oil price shock, Kilian (2006) emphasises that policy makers should consider the source of an oil price shock. He proposes a new index to proxy real global economic activities based on freight rates. Using this index, he decomposes the source of an oil price shock during the period from 1975 to 2005 into four components. The first two are supply shocks associated with political events in OPEC countries and other supply shocks. The other two components are associated with demand shocks, such as demand from industrial countries and demand related to higher

precautions, driven by fears about oil supplies in the future. He finds that the recent oil price shock of the 2000s is entirely attributable to aggregate demand shocks.

He also identifies the effect of these types of oil shock to both GDP and CPI in the US. The oil price shock that is linked to aggregate demand tends to raise US GDP in the short run and raises CPI in the long run. The oil price shock that is related to precautionary demand lowers US GDP, and at the same time raises CPI in the long run. The oil price shock related to political events causes US GDP to decline in the long run, but has no significant effects on CPI. Other supply disruptions cause US GDP to decline in the short run and lower CPI in the long run.

Segal (2007) provides a comprehensive review of the literature on the reduced effect of oil prices. He reaches three conclusions. First, that the effect of oil prices on output is not as serious as commonly thought. Second, monetary policy had a greater role in the economic downturn in the 1970s, rather than the oil price. Third, there is recent evidence that a rise in the price of oil is not directly associated with a recession. This is because of the very small pass through effect of oil price on inflation, especially core inflation.

In addition to the oil price, other commodity prices such as food prices also have a major impact on the rate of inflation, especially in developing economies. The proportion of food consumption was more than one third of household consumption in developing economies in the 2000s. In contrast, it was only ten percent in advanced economies. Developing countries also tend to be considerably more energy intensive. Meanwhile, the energy intensity, or the energy consumption per unit, of real GDP in advanced countries has fallen by around forty percent since the 1970s (IMF, 2008). For developing Asia, which consumes more food than developed countries, world food prices influence the

economy substantially. Rice and wheat prices are the two components that spiked in the last quarter of 2007 and at the beginning of 2008. This fuelled inflation in the region and spread fears of a food crisis throughout developing Asia, since these two products are the most important items in the basket of consumption in Asia (rice for south and east Asia and wheat for north and west Asia⁸).

Cecchetti and Moessner (2008) investigate the effect of commodity prices, including food and oil prices, on domestic inflation in both advanced and emerging economies. The purpose of their study is to answer three questions. First, does headline inflation revert to core inflation or vice versa? If the former happens, it implies there is little or no second round effect. The monetary authority should not respond. However, if the latter happens, this signals that there is a second round effect. In this case the monetary authority should take action. Using monthly data year on year of sample period 1994-2008, they find that inflation in the majority of these countries reverts to the long run equilibrium, especially during the sub sample in 2003 ahead, when the sharp increase in the oil price occurs, implying that there is little second round effect.

Second, do food or energy prices help to predict headline inflation? They find that the food price predicts it better than the energy price, although sample limitation casts doubt on that influence. Third, they also investigate the persistence of food and energy prices. They use an AR model to measure inflation persistence. Their study shows that food prices are more persistent than oil prices in most of the countries. Overall, this study has demonstrated the importance of a food price shock in addition to an oil price shock on the movement of domestic prices. Given the persistence effect of the food price, the

⁸Wheat is produced and consumed evenly all over the world. Meanwhile, production and consumption of rice is concentrated in monsoon Asia. This means international trade in rice is very limited relative to its production and consumption. As a result, its price is more volatile than the wheat price.

monetary authority should have paid closer attention to the movement of world food prices.

Little research has to date examined the effect of world commodity prices, in particular food prices, on domestic inflation in Asia. The research papers concentrate on the impact of world oil prices. For instance, Cunado and Gracia (2005) examine the effect of oil price shock on economic activity and the consumer price index in six Asian countries: Malaysia, Japan, Singapore, South Korea, Philippines and Thailand. They use quarterly data for the period 1975Q1-2002Q2.

They utilise some alternative measurements of oil price shock, such as changes in the level of oil prices, increases in oil prices, net oil price increases (NOPI) and scaled oil prices (SOPI). They use NOPI, following Hamilton (1996), who argues that it is more appropriate to measure the shock by comparing oil prices over the previous year rather than just the previous quarter. They also use SOPI, following Lee et al. (1995), and argue that oil prices tend to have a greater impact when relatively steady. If the oil price is erratic and volatile, price changes are likely to be quickly reversed. They also test the impact when the oil price is in USD and the domestic currency. In summary, their findings are that first, the impact of the real oil price in terms of a local currency is higher than that in the world price. This is due to the role of the exchange rate on macroeconomic variables. Second, an oil price shock in the local currency has a significant effect on inflation in all those countries being studied. This relationship appears to be stronger than that between the oil price and the level of economic activity.

Tilak (2001) also focuses on the effect of the oil price on economic growth in ASEAN4 (Indonesia, Malaysia, Philippines and Thailand), NIE4 (Hong Kong, South Korea, Singapore and Taiwan), China, Japan, the USA, and the rest of the OECD as a

group (ROECD) using a VARX model and 1982Q1–2000Q2 data. He finds that a rise in oil prices does lower economic growth, regardless of whether that economy is a net oil exporter or importer.

Jongwanich and Park (2009) examine the effect of international shocks on inflation expectations. They estimate a VAR model with Cholesky decomposition for nine countries in Asia using quarterly data from 1996Q1-2009Q1. These countries are China, India, Indonesia, Korea, Malaysia, Philippines, Singapore, Thailand and Vietnam. The model applied is based on McCarthy (2000), considering food prices as additional variables.

The transmission mechanism in their model starts from oil and food prices as a source of international shock to consumer price levels. These shocks affect aggregate demand and the balance of payments position. The conditions of these two change the nominal exchange rate. Finally, those shocks influence import, producer and consumer prices respectively. On the other hand, inflation expectations influence each stage of the transmission mechanism. The inflation expectation variable is based on information available in the previous period, following McCarthy (2000). The argument is that a backward looking variable is better for explaining domestic prices in developing Asia. Unfortunately, there is no reliable indicator that would capture the forward-looking one. The variance decomposition shows that external shock has a bigger impact on producer prices than on consumer price inflation. The oil price dominates the movement of producer price inflation across countries except for India, Indonesia and Korea. In those three countries, oil and food prices are equally important. Exchange rate movement also explains much of the producer price inflation and consumer price inflation in Korea and Indonesia. Other shocks that influence consumer price inflation are food and oil prices. Food prices have a greater affect than oil prices, except in Singapore. It is also worth noting that excess

demand and inflation expectations can account for much of the consumer price inflation across countries. Overall, their findings conflict with the view that the surge in inflation in this region is beyond monetary policy control, given international shocks such as those affecting oil and food prices. Monetary policy is still important in influencing inflation expectations. Monetary policy tightening can reduce the impact of global shocks on any inflation expectation.

We intend to extend the research on the effect of world commodity price shocks on domestic inflation in Asia. Unlike most of the previous literature, we shall give emphasis to the effect of world commodity prices in the form of first pass through and second pass through on domestic inflation. This allows us to separate the direct effect of the shock and to establish whether its effect is permanent or not. Furthermore, as food prices have soared recently, we shall investigate the effect of world food prices on domestic prices, in addition to the effect of world oil prices. This part also provides an additional contribution, given the paucity of research on the effect of world food prices shocks.

3.3. Methodology and Data

3.3.1. Methodology

The above research questions consider the pass through effect of world oil and food price shock to domestic inflation. This pass through effect can be direct (first round) and indirect (second round). The first round effect is determined by the weight of those prices on consumption expenditure in the construction of the rate of headline inflation. The second round effect is linked to supply and demand conditions. For instance, increasing transportation costs because of rising oil prices will increase production costs and may limit supply, and hence will exert pressure on inflation. Inflation expectations can also

contribute to explaining the second pass through. If the monetary authority is credible enough in combating inflation, the shock should barely alter inflation expectations: the second pass through will be minimal. Otherwise, the shock will influence medium and long run inflation indefinitely.

Two main methodologies for addressing this issue use a system of equations, such as a VAR model or a single equation model. The advantage of VAR is that we can have a picture of the magnitude and response time of a variable to a shock. We can also estimate the first and second pass through in one model. However, (the) VAR requires identification of the shocks, which is subjective and debatable. For example, it needs to be decided which variable is the most endogenous in the system: oil price, food price or monetary policy shock. This could vary greatly between countries, given their different characteristics, and will make results hard to compare. A single equation approach includes an Autoregressive Distributed Lag (ARDL) model, which is simpler and more straightforward, making the findings more comparable. This approach calls for estimation step by step, separating the first pass through from the second pass through. Following IMF (2008), we employ the latter method to measure the pass through of world commodity inflation to domestic inflation for the first round effect. The specification of the two separate models is as follows:

$$\pi_t^{domestic\ food} = \alpha + \sum_{i=1}^{n1} \beta_i \pi_{t-i}^{domestic\ food} + \sum_{i=0}^{n2} \delta_i \pi_{t-i}^{world\ food} + \varepsilon_t \quad (3.1)$$

$$\pi_t^{domestic\ fuel} = \alpha + \sum_{i=1}^{n1} \beta_i \pi_{t-i}^{domestic\ fuel} + \sum_{i=0}^{n2} \delta_i \pi_{t-i}^{world\ oil} + \varepsilon_t \quad (3.2)$$

where the first pass through $= \frac{\sum_{i=1}^{n2} \delta_i}{1 - \sum_{i=1}^{n1} \beta_i}$ for each equation. This implies the full pass through of world inflation to domestic inflation. Domestic inflation can be domestic food inflation ($\pi^{domestic\ food}$) or domestic fuel inflation ($\pi^{domestic\ fuel}$). World inflation can be

either world food inflation ($\pi^{world\ food}$) or world oil inflation ($\pi^{world\ oil}$). The exchange rate can interact with this world commodity inflation and influence the degree of the first pass through, as we show later.

Meanwhile, to calculate the second round effect we estimate the Phillips curve equation, where the dependent variable is core inflation. The model is based on Fuhrer (1995) and Hooker (2002) and is also adopted by Gregorio, Landerretche and Neilson (2007) and IMF (2008) as follows:

$$\pi_t^{core} = \alpha + \sum_{i=1}^{n1} \beta_i \pi_{t-i}^{core} + \sum_{i=0}^{n2} \gamma_i (y_{t-i} - y_{t-i}^*) + \sum_{i=0}^{n3} \theta_i \pi_{t-i}^{domestic\ food} + \sum_{i=0}^{n4} \rho_i \pi_{t-i}^{domestic\ fuel} + \varepsilon_t \quad (3.3)$$

where π_t^{core} is the core inflation rate, $y_{t-i} - y_{t-i}^*$ is the output gap⁹, $\pi_{t-i}^{domestic\ food}$ and $\pi_{t-i}^{domestic\ fuel}$ are the domestic food inflation and domestic fuel inflation rates respectively.

The food and oil second pass through are $\frac{\sum_{i=1}^{n3} \theta_i}{1 - \sum_{i=1}^{n1} \beta_i}$ and $\frac{\sum_{i=1}^{n4} \rho_i}{1 - \sum_{i=1}^{n1} \beta_i}$. These two imply the full pass through of domestic food inflation and domestic fuel inflation to core inflation.

There is a possibility that domestic food and fuel inflation rates are endogenous in the equation above. Domestic food and fuel inflation are often determined by domestic costs such as labour costs and distribution costs that are included in core inflation. To eliminate this endogeneity problem, we shall employ forecast value of domestic food and fuel inflation of equation (3.1) and (3.2) as instrumental variables in equation (3.3). In this way, the domestic food and fuel inflation included in the estimation exclude the domestic cost in the core inflation. These variables are only determined by their lags and world oil or food inflation.

⁹The coefficient of output gap reflects the response of rate of inflation to the changes of output gap. In some estimations, it is the response to the growth of the output gap because the level of the output gap is non-stationary.

To find the parsimonious model of (3.1), (3.2), and (3.3) we reduce the number of lags by considering the significance of the coefficients, the lag criteria and the goodness of fit. It is widely known that including a lag dependent variable as an explanatory variable and the presence of autocorrelation in the disturbance will result in the OLS estimator becoming both biased and inconsistent. Thus, we always perform a diagnostic test, testing particularly for serial correlation, in the process to find the parsimonious model so that OLS is still an efficient estimator. We check the serial correlation using the Lagrange Multiplier (LM) test, since the Durbin Watson (DW) test is biased in the presence of a lag dependent variable. Moreover, we compute the standard error using heteroskedasticity and autocorrelation consistent (HAC), with the Newey-West (1987) method. In addition, we also perform a Wald test to check the restriction that all the coefficients of the related variables are significantly different from zero or not.

The specification of equation (3.3) could contain errors. A specification error might be due to the number of lags included and the instrumental variables employed. To confirm the results of equation (3.3) we also use another model, as in Cecchetti and Moessner (2008), to check whether there is a second round effect or not. They check whether headline inflation reverts to core inflation or not, using the following specification:

$$\pi_t^{headline} - \pi_{t-n}^{headline} = \alpha + \beta(\pi_{t-n}^{headline} - \pi_{t-n}^{core}) + \varepsilon_t \quad (3.4)$$

This specification is initially used by Cogley (2002) to evaluate some core inflation measurements. Bryan and Cecchetti (1994) define core inflation as “the component of price changes that is expected to persist over medium-run horizons of several years”. Mathematically, $\pi_{ct} = E_t \pi_{t+n}$. Following this definition, a good measurement of core inflation will generate $\alpha = 0$ and $\beta = -1$. If β is negative and its absolute value is less

than one, the core deviation is said to overstate the magnitude of inflation changes. If it is greater than one, it understates the change of inflation.

In our case, we assume the core inflation to be correct. If headline inflation reverts to core inflation, it implies there is little or no second round effect. That is reflected by the coefficient β that is negative. This implies that headline inflation has returned to its long-term equilibrium where it is close to core inflation. The closer the absolute value of β to one, the less the second pass through. In other words, the rate of inflation reverts back to core inflation more quickly.

We can also test the reverse effect by estimating this specification.

$$\pi_t^{core} - \pi_{t-n}^{core} = \alpha + \delta(\pi_{t-n}^{core} - \pi_{t-n}^{headline}) + \varepsilon_t \quad (3.5)$$

If the data cannot reject the value of $\delta = 0$, this would imply that the core inflation is stable and does not revert to the headline inflation rate. However, if the data show that δ is negative, core inflation tends to revert to headline inflation or there is second pass through. $\delta = -1$ means core inflation fully reverts to headline inflation. Cecchetti and Moessner (2008) set $n=12$ in equations (3.4) and (3.5) to capture the reversion only in a one year period. To capture the evolution of the coefficient of reverting, we shall explore several periods over two years ($n=24$) so that we can see the picture of the coefficient from one month up to two years.

Inflation persistence could also lead to the second pass through. If the effect of the shocks does not die out for a long time, this can affect inflation expectations. In that case, the shock could generate a second round effect. For instance, if the world price shocks generate an increase in domestic food or fuel inflation, and the effect does not disappear for a long time, the economic agents will consider that this effect is permanent. They will set their own prices in the light of the new, increased prices. Moreover, in the absence of

monetary policy reaction when needed, this should provoke a greater inflation expectation. As a result, the effect of the shock will go through to core inflation.

Following this argument, we also confirm the estimation result of equation (3.3) using the measurement of the persistence of domestic food and fuel inflation. If the persistence is considerably high, this indicates the high possibility of a second round effect. Equations (3.4) and (3.5) check the second round effect in general terms, without considering its source. By measuring the persistence of domestic food and fuel inflation, we can confirm the source of the second round effect, whether it comes from domestic food or domestic fuel inflation, or from both.

We use a univariate approach to calculate the persistence instead of a multivariate one, as we focus on the data generating process of the inflation. The objective is not to find the determinants of inflation, as in a multivariate approach. The univariate approach consists of four main methodologies: the sum of autoregressive coefficients in autoregressive (AR) specification, the spectrum at zero frequency, the largest autoregressive root, and the half-life. Andrew and Chen (1994) discuss these and argue that the sum of autoregressive coefficients is the best scalar measurement of persistence. All univariate approaches are essentially derived from this approach, and hence we employ it. In the $AR(p)$ process:

$$y_t = \alpha + \sum_{j=1}^p \beta_j y_{t-j} + \varepsilon_t \quad (3.6)$$

the cumulative impulse response function ($CIRF$) is simply given by $CIRF = \frac{1}{1-\rho}$, where ρ is the sum of autoregressive coefficients $\rho = \sum_{j=1}^p \beta_j$. We can also rewrite (3.6) as in the Augmented Dickey-Fuller (ADF) equation:

$$\Delta y_t = \alpha + \sum_{j=1}^{p-1} \psi_j \Delta y_{t-j} + (\rho - 1)y_{t-1} + \varepsilon_t \quad (3.7)$$

It is similar to the ADF unit root test, where $\psi_j = -\sum_{i=1+j}^p \beta_i$ and ρ is the coefficient of persistence.

In the classical normal regression model with fixed explanatory variables, the least square estimator is unbiased. However, the least square estimator in the $AR(p)$ model tends to be biased. In particular, bias for the sum of the autoregressive coefficients tends to be downward and large. To produce more reliable results we adopt the median unbiased estimator, as in Andrews and Chen (1994) to calculate the persistence.

Intuitively, the median unbiased estimator has an impartiality property that the probability of underestimation is equal to the probability of overestimation. By definition, the estimator $\hat{\rho}$ is the median unbiased estimator of ρ , the true value, if ρ is the median of estimator $\hat{\rho}$ in the parameter space (Andrews, 1993), or $\hat{\rho}_{LS} = m(\hat{\rho}_U)$. Suppose the least square estimator $\hat{\rho}$ in an AR model is 0.8, we should not use 0.8 as the estimator of ρ . Instead, we find the value ρ that yields the least square estimator $\hat{\rho}$ that has a median of 0.8, or $0.8 = m(\hat{\rho}_U)$.

The $AR(p)$ model in this approach is a modification of the ADF equation:

$$y_t = \alpha + \sum_{j=1}^{p-1} \psi_j \Delta y_{t-j} + \rho y_{t-1} + \varepsilon_t \quad (3.8)$$

We follow the procedure used in Andrews and Chen (1994):

1. Estimate equation (3.8) to obtain $\hat{\alpha}_{LS1}, \hat{\psi}_{1_{LS1}} \dots \hat{\psi}_{p_{LS1}}$, and $\hat{\rho}_{LS1}$.
2. Treat $\hat{\alpha}_{LS1}$ and $\hat{\psi}_{1_{LS1}} \dots \hat{\psi}_{p_{LS1}}$ as if they were the true parameters and perform a Monte Carlo procedure to generate a sequence for the estimator $\hat{\rho}_{U1}$.
3. Based on this sequence we can find the median unbiased estimator $\hat{\rho}_{U1}$ from:

$$\hat{\rho}_{U1} = 1 \text{ if } \hat{\rho}_{LS} > m(1)$$

$$\hat{\rho}_{U1} = m^{-1}(\hat{\rho}_{LS}) \text{ if } m(-1) < \hat{\rho}_{LS} < m(1)$$

$$\hat{\rho}_{U1} = -1 \text{ if } \hat{\rho}_{LS} \leq m(-1)$$

This implies that we find the median of the sequence, which is equal to $\hat{\rho}_{LS1}$ or

$$\hat{\rho}_{LS1} = m(\hat{\rho}_{U1}). \text{ As we want to find } \hat{\rho}_{U1}, \text{ we use } \hat{\rho}_{U1} = m^{-1}(\hat{\rho}_{LS1}).$$

4. Treat $\hat{\rho}_{U1}$ as the true autoregressive parameter and regress $y_t - \hat{\rho}_{U1}y_{t-1}$ on $1, \Delta y_{t-1}, \dots, \Delta y_{t-p}$ to find the estimates $\hat{\alpha}_{LS2}, \hat{\psi}_{1_{LS2}} \dots \hat{\psi}_{p_{LS2}}$
5. Now treat $\hat{\alpha}_{LS2}, \hat{\psi}_{1_{LS2}} \dots \hat{\psi}_{p_{LS2}}$ as the true parameter as in step 2 and repeat steps 2 and 3 to calculate $\hat{\rho}_{U2}$
6. Repeat until $\hat{\rho}_U$ converges or after a certain number of maximum iterations.

We execute this using the MatLab procedure “acmub.m” created by Maag (2009). To determine the number of lags we use the Schwarz criterion in the ADF test since this model is the modification of an ADF unit root test.

3.3.2. Data

For the domestic inflation of each country, we use data for headline inflation, domestic food inflation, domestic fuel inflation and the core inflation rate. However, for some countries (Hong Kong, Malaysia and Singapore), we have not found data for core inflation. We calculate the core inflation of these countries by excluding food and transportation items from the consumer price index and adjusting the weight of each component. Ideally, food and energy prices should be excluded from this calculation. However, unlike food, which has a special category, energy has no specific category in CPI, thus the data of the weight of this item are not available for these countries. Since we only have a transportation category, we exclude this category because fuel is mostly used as a transportation item. Moreover, other means of energy, which are also sub parts of housing, have a relatively small weight in this instance and so will not change the index significantly. All these data are in index form.

All price data and real GDP data are seasonally adjusted. We calculate the output gap from the log of real GDP minus their potential output. We use an HP filter to calculate the potential output and for the exchange rates we use nominal ones. For the world price we include two main indices, world oil prices and food prices. These indices are generated from world prices in USD: for instance, the oil price is in USD/bbl.

We use quarterly data, in quarter-to-quarter form, for most of the estimation. For the estimation in equations (3.4) and (3.5) we use monthly data in month-to-month form as we include a longer lag. We convert the price indices into the form of an inflation rate. All the indices of world prices are taken from the IFS-IMF. A country's data is mostly taken from CEIC, country statistical institutions and central banks. Data descriptions are provided in appendix 3.1.

3.4. Estimation Results

We perform unit root tests for all variables in terms of the difference in log levels. We use an ADF test with lag based on lag criteria to ensure there is no serial correlation in the ADF equation. Based on unit root tests, most of the variables are $I(0)$ except for output gap in some countries. We can reject the unit root at significance level of five percent.

3.4.1. First Pass Through

We estimate equation (3.1) to find the coefficient of the first pass through of each index. For the first pass through of the world oil price, the dependent variable is the domestic fuel price. For world food prices, the dependent variable is the domestic food price. All of the data are in log difference so that we have the inflation rate. We start from lag four because the longer lags are insignificant; this implies that the effect of world commodity prices diminishes after one year. Another reason is the sample adequacy. With

the sample from 2000Q1 to 2010Q1 we have only 41 observations and adding more lags would reduce the degree of freedom. The complete estimation results can be found in Appendix 3.4. Below is a summary of the estimation results based on a significance level of the coefficients of at least 90 percent:

Table 3.1. First Pass Through of World Oil and Food Price

Country	Food First Pass Through		Oil First Pass Through	
Hong Kong	0.277	***	0.229	**
Indonesia	0.509	***	0.182	**
Korea	0.027		0.200	***
Malaysia	0.313	***	0.387	*
Philippines	0.575	***	0.795	***
Singapore	0.089	***	0.799	***
Taiwan	0.110	*	0.332	***
Thailand	0.360	***	0.328	***

The long-run coefficient of ARDL equation as of equation (3.1) and (3.2)

*** p<0.01 ** p<0.05 * p<0.1, based on Wald test for joint hypotheses

(Ho): the coefficient of world food and oil inflation equals to zero in eq.(3.1) and (3.2)

Various factors influence the degree of first pass through of world oil and food prices. These include subsidies, taxes, domestic costs such as retailing and distribution costs, and the demand for food or fuel.

The first pass through of oil is closely related to fuel subsidy in a country. Although the exact level of subsidy is difficult to measure, as it is often hidden (Jha et al., 2009), some facts in the countries under investigation indicate that there is a strong relationship between the two. Indonesia has the lowest first pass through of oil, at 0.182. This is because the energy subsidy (fuel and electricity) in Indonesia is relatively high. The level of subsidy also fluctuates in response to world oil price fluctuation. As the domestic fuel price is capped, the subsidy tends to display large covariance with the world oil price later. Following sustained rises in the price of oil, the fuel subsidy policy was reformed substantially in 2005Q4. The subsidy was eliminated from the industrial sector, but was

maintained for both household and transportation sectors. The fuel subsidy includes low-octane gasoline, kerosene, diesel, LPG and electricity; however, this subsidy remains high even after price adjustment. The lowest pass through in this country is related to the fuel subsidy allocation, which is high during the period of study.

Table 3.2. Prevalence of Oil Subsidies

Country	Oil First Pass Through	Fuel Subsidy ¹ (%GDP)	Subsidy on Gasoline?	Subsidy on Diesel?	Subsidy on Kerosene?	Other Subsidy?	Regulated Price?
Indonesia	0.182	2.7	Yes	Yes	Yes	No	Yes
Korea	0.200	0.4	No	No	N.A.	Yes	No
Hong Kong	0.229	0.0	No	No	N.A.	No	No
Thailand	0.328	0.8	No	Yes	No	Yes	No
Taiwan	0.332	1.3	Yes	Yes	N.A.	Yes	Yes
Malaysia	0.387	2.6	Yes	Yes	No	Yes	Yes
Philippines	0.795	0.2	No	No	No	Yes	No
Singapore	0.799	0.0	No	No	N.A.	No	No

Source: Jha, et al., (2009); 1. Based on 2008 (CEIC, UOB)

N.A.: Not Applicable

Other countries also have a low first pass through, which is because they still subsidise fuel products. Korea, even though it does not regulate fuel prices, has offered fuel tax exemptions since 2000, which function as a subsidy. The main part of this tax exemption benefits public transportation, and business entities that use lorries also benefit from this tax exemption, which helps reduce the direct impact of oil prices. Taiwan and Thailand also give subsidies. Taiwan still subsidises gasoline and diesel in the form of different pricing for different economic classes and its fuel price is regulated. Thailand still allocates a subsidy for diesel usage by state-owned companies and Malaysia allocates a subsidy for its transportation and fisheries (Jha et al., 2009); as in Indonesia and Taiwan, its fuel price is regulated. The subsidy increased substantially from 7.7 percent in 2000 to 17.4 percent of total expenditure in 2008 (Narayan, 2007) and includes fuel, cooking oil, flour, bread and imported rice. Fuel itself has the highest proportion, at around 54 percent.

As reducing the budget deficit became a main concern for the government, the fuel price was allowed to rise when the world oil price increased sharply. The regulated fuel price increased five times between May 2004 and February 2008 in order to reduce the budget deficit. This continuous increase made the first pass through of oil in Malaysia higher than in the other countries in the period of estimation, even though its subsidies were relatively high.

Hong Kong does not subsidise fuel or regulate its fuel prices, but its first pass through of oil is relatively small. It sees a minimum direct impact of oil price because its economy is highly service-oriented and less dependent on oil. According to the Hong Kong Economic Report (2011), fuel costs accounted for around only four percent of total business costs; moreover, more than half the sources of energy come from coal. High population density and high taxes on motoring are also reasons for this, with Hong Kong imposing high taxes on private motor vehicles and on petrol. This encourages the use of energy-efficient public transportation, thus reducing the pass through of oil prices.

Among the countries under investigation, we find that Singapore has the largest first pass through of oil, at 0.799. This indicates that the domestic fuel price in Singapore mostly follows the world price, mirroring it almost exactly. Singapore does not allocate any subsidies for domestic fuel prices. Philippines also has a high first pass through. This country does not have explicit subsidies for fuel products such as gasoline, diesel or kerosene. During periods of high oil prices, the subsidy is specific, in the form of 1-2 pesos per litre for diesel for public utility vehicles. However, this form of subsidy is trivial.

The estimation result shows that Korea has a relatively low level of first pass through for food. It is even insignificant, according to the Wald test result. On the other hand, Philippines has the highest first pass through of food. Other countries such as

Indonesia, Thailand and Malaysia also have a relatively high first pass through of food, which is related to high dependency on imported foods. A higher dependency on imported food should cause a higher first pass through. However, this relationship is not clear in these countries. Even Singapore, which relies heavily on imported food, has a low first pass through of food. Indonesia and Philippines, which have a low ratio of imported food, have a high first pass through. We infer that other factors explain this first pass through.

Table 3.3. First Pass Through of Food and Related Indicators

Country	Food First Pass Through	Food Subsidy (%GDP) ¹	Ratio of imported food to Food Cons.(%) ²	Ratio of food to private cons.(%) ³	Food weight in CPI (%) ⁴	GDP per capita in USD ⁵
Korea	0.027	0.0	16.420	14.380	14.000	15,771.600
Singapore	0.089	0.0	98.300	7.423	23.380	28,602.000
Taiwan	0.110	0.0	9.110	12.288	25.000	14,990.667
Hong Kong	0.277	0.0	61.570	13.760	26.940	26,706.075
Malaysia	0.313	0.7	26.930	24.995	30.000	5,445.479
Thailand	0.360	0.1	15.620	20.424	32.710	2,847.686
Indonesia	0.509	0.2	4.510	48.628	42.300	1,320.884
Philippines	0.575	3.4	9.590	53.489	46.580	1,258.970

1. CEIC, UOB (2008); 2. average 2000-2003; 3.average 2000-2010; 4.ADB(2008); 5. average 2000-2009

Data for the ratio of food to private consumption and the weight of food in CPI point to a clear relationship that might explain the first pass through of food in these countries. The countries that can be grouped as developing countries, as shown by their GDP per capita, such as Malaysia, Thailand, Indonesia and Philippines, have a high ratio of food consumption and a greater weight in the CPI basket. This ratio implies a high demand for food in these countries. For instance, rice is a basic food for them, so given their high demand for it, some of these countries import rice, with Philippines the leading importer in the world in 2007 (ADB, 2008). Given this high demand, combined with the small number of sellers, the world food price shock will be transmitted more to consumers. This can be reflected in a high first pass through of food. The high proportion of food

consumption in these countries makes these countries more vulnerable relative to the others. Given this, the governments in these countries allocate food subsidies in the form of price control and consumer and producer subsidies to increase supply. This helps dampen the impact of the increase in world food prices, but the high demand influences the impact more significantly. As a result, the first pass through of food in these countries is still relatively higher than in more developed countries.

More developed countries display a lower first pass through of food. There might be a wider choice of food products, which makes the demand more elastic in these countries or there might also be a larger proportion of other costs, in addition to the commodity price itself, such as processing, packing, distribution and marketing costs, which create more space for the intermediate processor to absorb the shock. This creates buffers for the final consumers from world commodity price shocks, lowering the first pass through of food. Another explanation is market intervention to stabilise prices. For instance, the Korean government stabilises the price of rice to maintain the rice production of its local farmers. This contributes to a low first pass through of food in this country.

3.4.2. The Role of Exchange Rate in the First Pass Through

The exchange rate usually adjusts when a foreign shock occurs; for example, as a result of monetary policies being tightened. This adjustment dampens the direct effect of foreign shock. We re-estimated the models in the previous section by including a nominal exchange rate that interacts with world commodity prices to observe the role of the rate. We modify equations (3.1) and (3.2) as follows:

$$\pi_t^{domestic\ food} = \alpha + \sum_{i=1}^{n1} \beta_i \pi_{t-i}^{domestic\ food} + \sum_{i=0}^{n2} \delta_i (\pi_{t-i}^{world\ food} + e_{t-i}) + \varepsilon_t \quad (3.9)$$

$$\pi_t^{domestic\ fuel} = \alpha + \sum_{i=1}^{n1} \beta_i \pi_{t-i}^{domestic\ fuel} + \sum_{i=0}^{n2} \delta_i (\pi_{t-i}^{world\ oil} + e_{t-i}) + \varepsilon_t \quad (3.10)$$

where e is the exchange rate in log difference. The model specification follows the literature that measures the exchange rate pass through. The specification can impose restrictions that the coefficient of foreign prices and exchange rates are the same (e.g. Gagnon and Ihrig, 2004), or relax that restriction (e.g. Campa and Goldberg, 2005). We follow the former, to capture the role of the exchange rate when it interacts with world commodity prices in every lag quarter, not to capture the exchange rate pass through. If we relax that restriction, the significance of the exchange rate could be in a different quarter from that of world commodity prices, hence the interaction does not always exist in every quarter. Moreover, the coefficient will not reflect the interaction between the two variables, but the pass through of the world commodity price when the exchange rate is controlled.

We compare equation (3.1) with (3.9) for domestic food inflation and equation (3.2) with (3.10) for domestic fuel inflation. The difference between coefficient δ in these equations can be interpreted as how much the role of the exchange rate to the first pass through of world commodity prices is. It also implies the elasticity of the world commodity price in terms of domestic currency. We use a nominal exchange rate (USD/national currency) in line with the index of world oil and food prices that are derived from USD unit prices. We expect the coefficient of interaction between world commodity prices and exchange rate will be less than that without interaction.

Table 3.4 demonstrates that the exchange rate in Hong Kong does not influence the first pass through, since Hong Kong pegs its dollar to the USD. HKMA introduced a Currency Board in October 1983 and the HK dollar (HKD) is rigidly linked to the USD at the rate of 7.8 HKD/USD. The first pass through of oil prices in Singapore is still relatively high (around 0.7) after the interaction with the exchange rate. Taiwan, like other countries

that stabilise their exchange rate, does not show a major role of exchange rates in reducing the first pass through.

Table 3.4. The Difference in the First Pass-Through after Interaction with the Exchange Rate

Country	First Pass Through of Oil			First Pass Through of Food		
	A	B	A-B	A	B	A-B
Hong Kong	0.229	0.229	0.000	0.277	0.277	0.000
Indonesia	0.182	0.140	0.043	0.509	0.108	0.401
Korea	0.200	0.147	0.053	0.027	-0.027	0.054
Malaysia	0.387	0.387	0.000	0.313	0.284	0.030
Philippines	0.795	0.712	0.084	0.575	0.232	0.344
Singapore	0.799	0.709	0.090	0.089	0.067	0.022
Taiwan	0.332	0.291	0.041	0.110	0.102	0.009
Thailand	0.328	0.306	0.023	0.360	0.233	0.127

A: the full pass through coefficient of world oil or food inflation as in ARDL equation 3.1 and 3.2 where there is no exchange rate interaction with world oil or food price

B: The same as A but with exchange rate interaction

Indonesia's exchange rate reduces the first pass through considerably, especially for food prices; Philippines demonstrates a similarity with Indonesia. The first pass through of oil prices is also reduced. The exchange rate is the shock absorber for both oil and food price shock in these countries. The role of exchange rates in absorbing world oil and food price shocks in Malaysia is not as large as in Indonesia and Philippines. One explanation is that from 1998 to 2005, Malaysia pursued bilateral exchange rate stability against the USD, later (on 21 July 2005) adopting an effective exchange rate system with greater flexibility. The first pass through of Thailand also decreases as world oil and food prices interact with its exchange rate, but to a lower degree. This country is one of the main rice producers of the world. This means supply factors influence domestic food prices significantly. Hence, the role of the exchange rate in the first pass through of food is less than that in other developing countries that float their exchange rates, such as Philippines and Indonesia. The exchange rate in Korea also reduces the first pass through of food and

oil prices. For food prices, its first pass through becomes negative as it interacts with the exchange rate. There is a possibility that exchange rates appreciate significantly when world food prices increase, so the rise in domestic food prices is reversed.

Overall, the role of the exchange rate in the first pass through of oil prices is not as large as in that of the first pass through of food prices. The possible explanation is that of fuel price regulation. Oil price shocks happen more often, so the effect of these shocks is anticipated more. As a result, governments issue more regulations to control the fluctuation of the oil price shocks. This makes the role of the exchange rate in the first pass through of oil less than in the first pass through of food.

3.4.3. Second Pass Through

We estimate equation (3.3) to demonstrate the second pass through of world oil and food inflation to domestic inflation. As mentioned in the previous section, we use the forecast result of equations (3.1) and (3.2) as instrumental variables of domestic food and fuel inflation respectively. This enables us to avoid the endogeneity problem. As in equations (3.1) and (3.2), we reduce the number of lags up to the significant ones to obtain the parsimonious equation. Table 3.5 summarises the estimation result.

Table 3.5. Second Pass Through

Country	Second Pass Through of Oil		Second Pass Through of Food	
Hong Kong	0.000		0.717	**
Indonesia	0.081	***	0.000	
Korea	0.000		0.000	
Malaysia	0.000		0.159	***
Philippines	0.063	***	0.329	**
Singapore	0.000		0.737	***
Taiwan	0.000		0.016	***
Thailand	0.079	***	0.000	

Above coefficients are long-run multiplier in ARDL model as in eq.3.3

*** p<0.01 ** p<0.05 * p<0.1, based on Wald test for joint hypotheses

(Ho) the coefficient of domestic food or oil inflation equals to zero.

For Hong Kong, Philippines, and Singapore, we use the log difference of output gaps because the log level of output gaps is non-stationary. In this case, aggregate demand is represented by the growth of the output gap. For other countries we use the log level of the output gap as in the standard Philips Curve equation. For the equations that have second pass through of food or oil, the estimation results show that the Wald test rejects the joint hypothesis that the coefficient of all lags of domestic food or fuel inflation are equal to zero. In terms of oil, all countries have a relatively small second pass through, at less than 0.1. Even countries such as Hong Kong, Korea, Singapore and Taiwan have zero second pass through for oil. On the other hand, in terms of food, some countries have a relatively high second pass through. Hong Kong and Singapore have noticeably high second pass through, at 0.717 and 0.737 respectively. Other countries have less than 0.5 and Indonesia, Korea and Thailand show no second pass through of food. In Philippines it is larger (0.329), perhaps because of the high demand for food which makes this country the world's top rice importer (ADB, 2008). Overall, the estimation results show relatively small, or no, second pass through for food and oil, except for Singapore and Hong Kong.

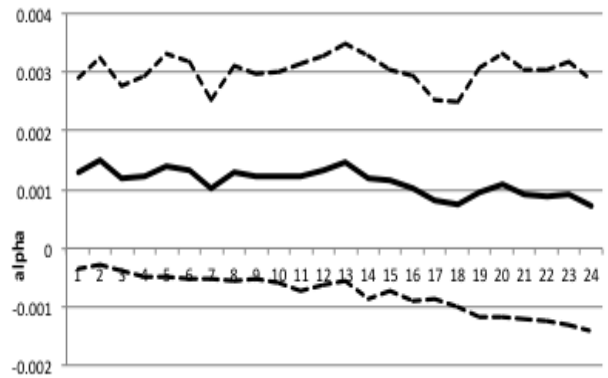
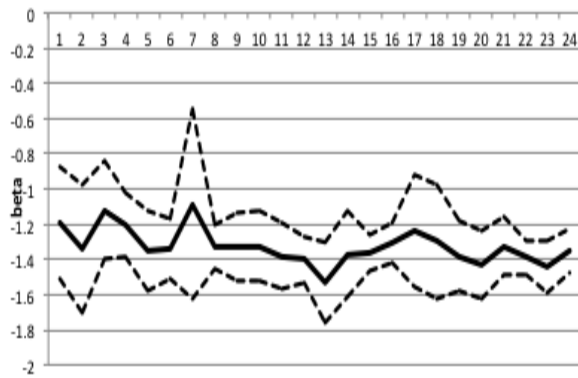
One factor that results in a small second pass through is the greater proportion of domestic costs in core inflation relative to the world prices themselves. These domestic costs include those of labour, processing, distribution, marketing and others. As a result, this offsets the positive effect of commodity prices on core inflation. Another factor is the monetary policy that contributes to the price stability of the countries. For example, the implementation of ITF in some of the countries under investigation helps to lead the inflation expectation of the agents of the economy. As ITF emphasises transparency and accountability, what becomes the target and how the monetary authority takes action to reach this target are clearer. Moreover, some countries use core inflation as their target.

This contributes to reducing the impact of world commodity prices at the second stage, thus the second pass through is minimal in most countries.

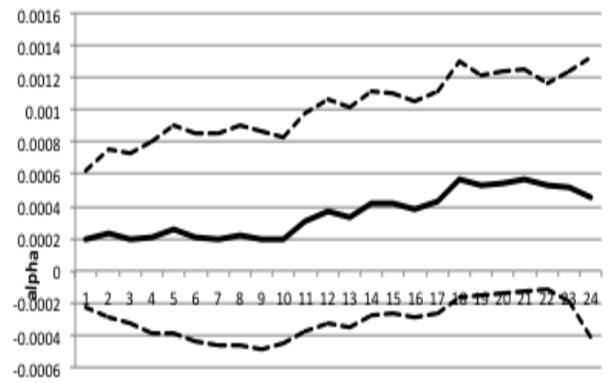
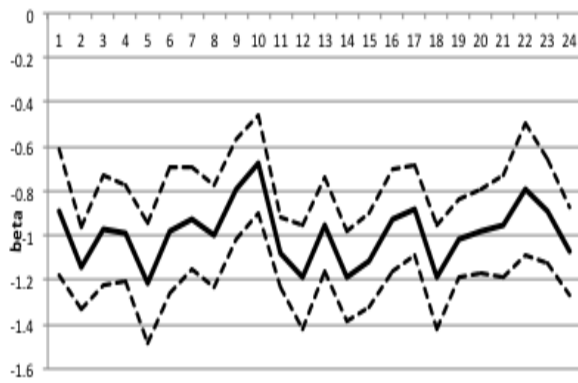
As mentioned previously, the specification of a second pass through equation has potential specification errors. These might come from the number of lags included, the instrumental variables used in this equation or be due to other reasons. To confirm the results, we also check the existence of a second pass through by estimating equations (3.4) and (3.5), which evaluate whether headline inflation reverts to core inflation within a certain period and vice versa. For these estimations we use monthly data. Unlike Cecchetti and Moessner (2008), who use year-on-year monthly data, we use month-to-month monthly data to avoid non-stationary data. Given the monthly data, we expand the horizon up to 24 months. In this way, we check whether there is second pass through or not, from one month up to a horizon of two years.

In equation (3.4) we expect the β coefficient to be negative, which means that headline inflation reverts to core inflation within a certain period. We also expect α to be zero, which implies that the mean of deviation is approximately zero. This in turn implies that the second pass through is minimal by assuming that core inflation is a representative of the long run equilibrium of inflation. In equation (3.5) we expect the δ coefficient to be zero or that core inflation does not revert to headline inflation. We estimate equations (3.4) and (3.5) with n equal to 1 to 24 months. Hence, we can see the change of the coefficient with different n . Graphically, the results of coefficient β and α , with a 95 percent confidence level, are as follows (we also provide the coefficient graphs of equation (3.5) in Appendix 3.3):

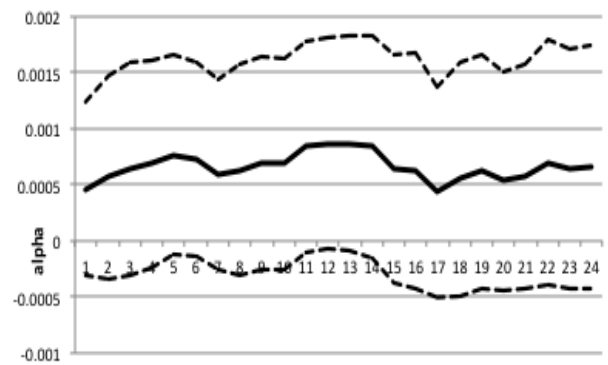
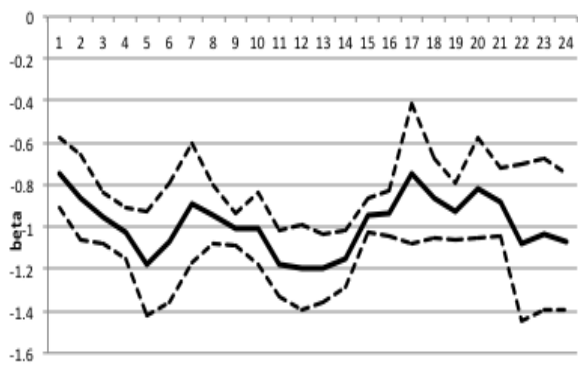
Indonesia



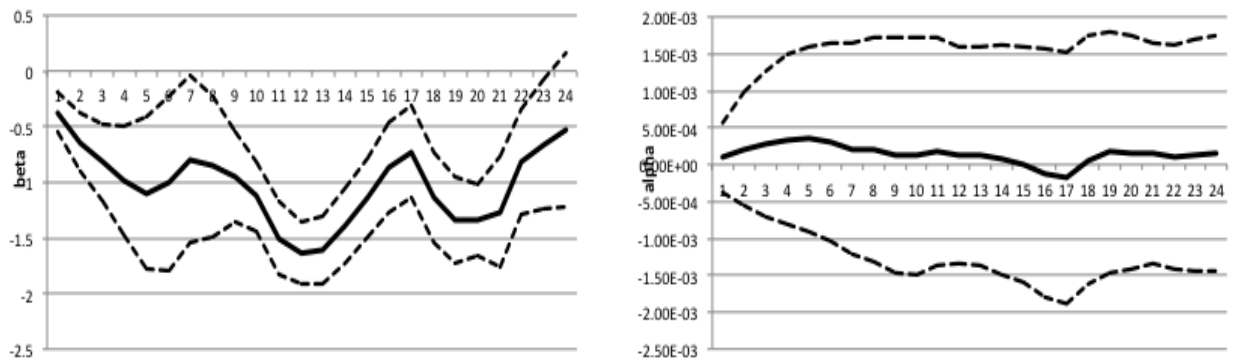
Korea



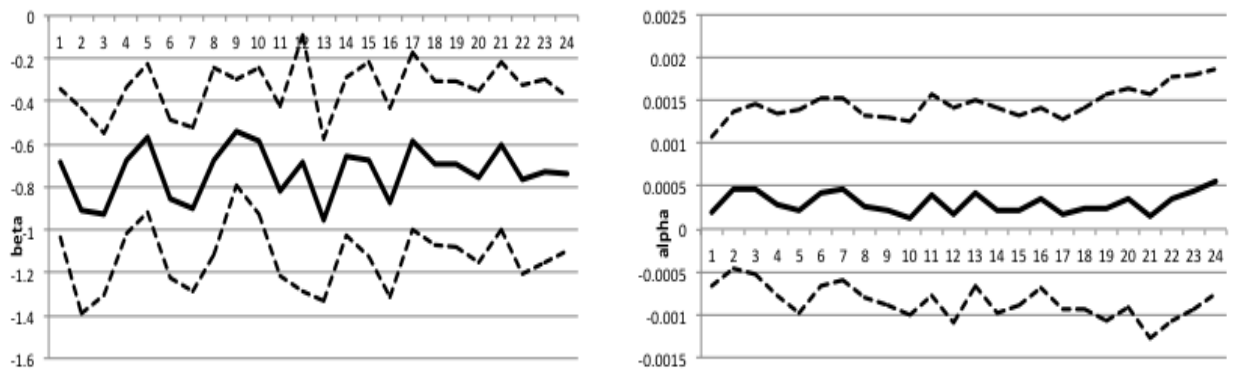
Malaysia



Philippines



Taiwan



Thailand

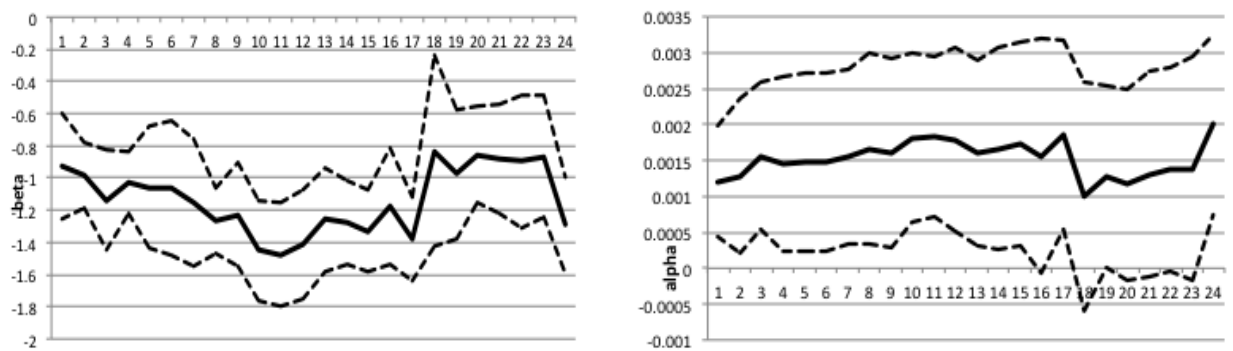


Figure 3.3. Beta and Alpha Coefficients for Indonesia, Korea, Malaysia, Philippines, Taiwan and Thailand

The above graphs show that the β coefficients of these countries are significantly negative. Even in some countries, such as Korea, the data cannot reject their β coefficient being different from -1 at most lag horizons. This implies that headline inflation fully reverts to core inflation and supports our finding of no second pass through for oil and food in Korea. Furthermore, neither can we reject that intercept (α) is different from or very close to zero. This implies that the mean of deviation is approximately zero. These graphs of beta and alpha confirm the previous estimation results, that the above countries have minimal second pass through.

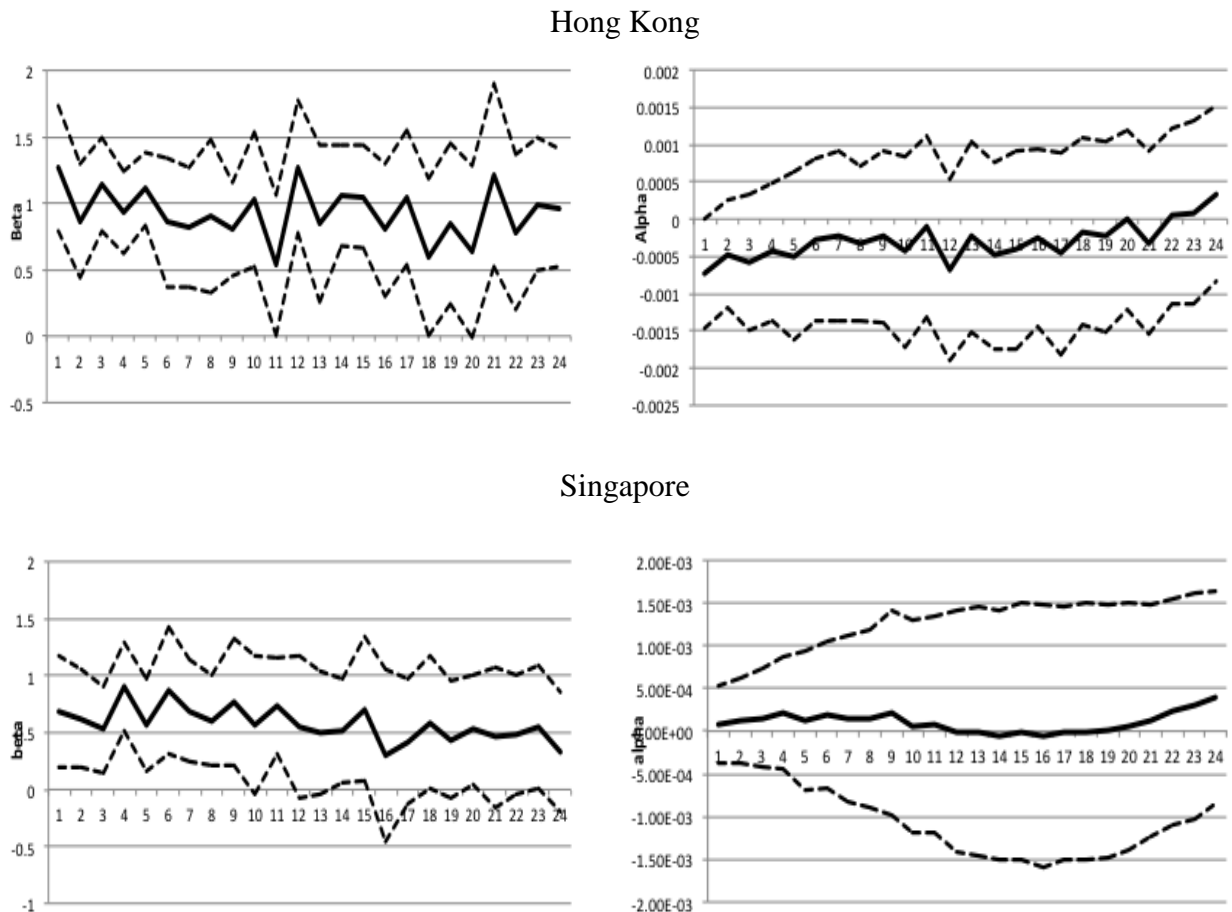


Figure 3.4. Beta and Alpha Coefficients for Hong Kong, and Singapore

On the other hand, we cannot reject the hypotheses that the β coefficients for Hong Kong and Singapore are positive. This implies that there is significant second pass through

in these countries because their headline inflation does not revert to core inflation. On average, the results seem to support the estimation results shown in table 3.6. However, there is a difference between them. The estimation of the second pass through in table 3.6 is specific on food and oil, while the later results are not specific; This is in terms of the aggregate of core and CPI inflation. Whether the different path between core and headline inflation is due to food or oil inflation is unclear.

In addition to the above estimation of the second pass through, we calculate the persistence of inflation. Theoretically, the existence of inflation persistence will impact on inflation expectations. As a result, there is a potential second round effect of world price shocks. To confirm whether the second round effect is due to food or oil inflation we look at the inflation persistence of both domestic food and fuel inflation. We employ an $AR(p)$ specification and follow the Andrews and Chen (1994) approach. With the Schwarz criteria, as in an ADF unit root test, we find all domestic and food inflation can be explained by the $AR(1)$ model. Given that, the equation (3.8) becomes $y_t = \alpha + \rho y_{t-1} + \varepsilon_t$. The estimation result is as follows:

Table 3.6. AR(1) Model of Domestic Fuel and Food Inflation

Country	Fuel Inflation		Food Inflation	
	α	ρ	α	ρ
Hong Kong	0.730	0.124	0.169	0.651
Indonesia	3.821	0.052	1.768	0.185
Korea	1.061	0.050	1.268	0.190
Malaysia	1.116	0.052	0.350	0.561
Philippines	1.985	0.361	0.913	0.297
Singapore	1.762	0.095	0.188	0.625
Taiwan	1.280	0.011	0.735	0.414
Thailand	1.335	0.138	0.722	0.315

*Above coefficients are based on median unbiased estimator as in Andrews and Chen (1994).

In general, the estimation results show that domestic food inflation is more persistent than domestic fuel inflation. This is in line with Cecchetti and Moessner (2008).

If we interpret the constant (α) as the mean of inflation, on average the mean of domestic fuel inflation is higher than that of food inflation. The high mean of domestic fuel inflation in Indonesia is due to the fuel subsidy reduction in 2005, making a significant increase in domestic fuel inflation in that country. Overall, the persistence of domestic fuel and food inflation is relatively small, being less than 0.5. An interesting point is the persistence of food inflation in Singapore and Hong Kong, exceeding 0.6. This is in line with the estimation of the second pass through of food prices as demonstrated in table 3.5. These two countries have a relatively high second pass through for food. This also clarifies why the headline inflation in these two countries does not revert to core inflation, as shown in figure 3.4. Domestic food inflation is the main cause.

The IMF (2008) argues that emerging and developing economies are more vulnerable to increases in world commodity prices than developed ones. This will be shown by a greater effect of world commodity price shock. The arguments are based on the fact that, in their consumption, developing countries have a larger share of world commodities. By dividing the countries under investigation into ASEAN4 and NIE4 groups, we can observe whether this finding is also valid in the first pass through of food. In this case, ASEAN4, Indonesia, Malaysia, Philippines and Thailand, are classified as developing countries. Meanwhile, NIE4, Hong Kong, Singapore, Korea and Taiwan, are classified as more developed ones. Developed countries are also thought to have a more credible monetary policy. Given this higher credibility, monetary policies in developed countries can anchor the inflation expectation more significantly, so that the effect of world commodity price shocks should be lower. This is reflected in the lower second round effect. However, the finding that demonstrates that Singapore and Hong Kong have high second pass through conflicts with this. Developed countries do not always have low pass

through of world commodity prices, even though they have a credible monetary policy. The high dependency of these countries on foreign supplies of food might results in a high second pass through. Countries like Singapore and Hong Kong rely heavily on foreign supply. World price shocks might lead economic agents to set higher food prices, which generates inflation expectation and eventually influences core inflation.

The results for the second pass through of each individual country (table 3.5) show that the second pass through of food in Singapore and Hong Kong is higher than for others. This is also reflected in figure 3.4, where the headline inflation in Singapore and Hong Kong cannot revert immediately to their core inflation, as demonstrated by positive β . Furthermore, the high domestic food inflation persistence in these countries also confirms the above result.

3.5. Conclusions

This chapter has studied the effect of world commodity prices on domestic prices. It gives emphasis to the first and the second pass through of world commodity prices to domestic prices. The period of this study is from 2000 onwards, when all commodity prices, including world food prices, soared. The chapter also includes world food prices so that it can contribute to the current literature, which mostly focuses on oil price movements. By focusing on Asian countries and including ASEAN4 and NIE4, this chapter also provides additional insights into the different effects of world commodity price movements in Asia's developing and developed countries. The research questions, which are related to the first and second pass through of world food and oil prices, have been answered. Based on the estimation results, we conclude the following.

Both the first pass through of world oil and food prices are significant during the period of investigation. On average, the first pass through of world oil price is higher than

for world food prices. This finding shows the world oil price matters in the countries under investigation. It is more significant than food prices. However, if we look at the individual countries, the results vary. In countries that still impose fuel subsidies or price ceilings, their first pass through is smaller. The greater the subsidy, the lower the first pass through. For example, the first pass through of oil in Indonesia is the smallest, given that the fuel subsidy remains significant. Regarding food prices, one possible explanation for a high first pass through of world prices is high food consumption. The greater the food consumption relative to other consumption, the higher the pass through. Countries such as Philippines, Indonesia, Thailand and Malaysia, which have high ratios of food consumption, tend to also have high first pass through of world food prices.

We also estimate the first pass through by interacting world prices with the exchange rate in order to capture the role of this rate. Overall, the role of the exchange rate in the first pass through of oil price is less than for food prices. So the exchange rate reduces the first pass through for oil price less than it does for food prices. This is shown by the difference between the coefficient of world commodity inflation before and after interaction with the exchange rate. A possible explanation for this is that most countries still impose a fuel subsidy. As oil price shock occurs more often than food price shock, governments might anticipate the shocks by imposing more regulations, which lessens the role of the exchange rate in absorbing world oil price shocks.

On average, the second pass through of both world food and oil prices is modest, except in Singapore and Hong Kong. The findings for these two countries are supported by estimation using the Phillips Curve, headline-core inflation reversion, and inflation persistence estimation. All three different estimations demonstrate that there is a relatively high second pass through in these two countries. Domestic food inflation is the cause. This

finding does not support the argument that the second pass through is relatively small in developed countries which generally have a lower inflation environment (Taylor, 2000). One should look in detail at what kinds of goods are included. The high degree of dependency of these countries on foreign supply might be the cause of the issue. In this situation, monetary policy might be less effective in dampening world price shocks.

Up to this point, the research in this chapter has answered the questions in the introduction. However, some limitations are worth noting at this point. First, we find an indication that the high first pass through of world food prices is closely related to the food consumption of a country instead of its dependency on imported food. This is an interesting topic to explore, in particular to measure which factor is more influential on the movement of domestic food prices.

Second, the estimations of the second pass through are based on the forecast value of the estimation of the first pass through as the instrumental variables to avoid the potential endogeneity problem. Even though we have confirmed the results by using other approaches, it would be interesting to estimate the second pass through using other instrumental variables, if available.

Third, we were unable to find data for core inflation for all the countries, in particular for Hong Kong and Singapore. If official data of core inflation become available, the models could be re-estimated for these two countries. This might confirm the conclusion that the second pass through of world commodity prices in these two countries is high.

Appendix 3.1. Data Description

Consumer Price Index

Country	Series	Source	Others
Hong Kong	CPI	CEIC	Index (2005=100)
Indonesia	CPI	Bank Indonesia	Index (2007=100)
Korea	CPI	CEIC	Index (2005=100)
Malaysia	CPI	CEIC	Index (2005=100)
Philippines	CPI	CEIC	Index (2000=100)
Singapore	CPI	CEIC	Index (2009=100)
Taiwan	CPI	CEIC	Index (2006=100)
Thailand	CPI	CEIC	Index (2007=100)

CPI - Food

Country	Series	Source	Other
Hong Kong	CPI-Food	CEIC	Index (2005=100)
Indonesia	Volatile Food (less than CPI- Food)	Bank Indonesia	Index (2007=100)
Korea	CPI-Food	CEIC	Index (2005=100)
Malaysia*	CPI-Food	CEIC	Index (2005=100)
Philippines	CPI-Food	CEIC	Index (2000=100)
Singapore	CPI-Food	CEIC	Index (2009=100)
Taiwan	CPI-Food	CEIC	Index (2006=100)
Thailand	CPI-Food & Beverage	CEIC	Index (2007=100)

*For Malaysia, there is a new classification from based year 2000 to 2005.
We connect the data using year on year growth.

CPI – Fuel

Country	Series	Source	Other
Hong Kong	Listed Price-Mtr Gasoline Unleaded petrol 98	CEIC	HKD/Ltr, end period; CPI-Tr-Fuel only fr 2004q1, indexed 2005=100
Indonesia	Gasoline-Premium	Bank Indonesia	Index (2007=100)
Korea	CPI-Trans-Fuel	CEIC	Index (2005=100)
Malaysia*	CPI-Trans-Fuel &Lubric. For 2005 onward and CPI- Trans &Comm- Operation Of Personal Transport for 2005 backward	CEIC	Index (2005=100)

Philippines	CPI-Services-Trans-Oil, Gasoline, Diesel	CEIC	Index (2000=100)
Singapore	Manuf.PPI-Fuels minerals	CEIC	Index (2006=100), adjusted 2009=100
Taiwan	CPI-TransCom- Fuel&Lub	CEIC	Index (2006=100)
Thailand	Non Core – Energy	CEIC	Index (2007=100)

*For Malaysia, there is a new classification from based year 2000 to 2005. We connect the data using year on year growth. It is also happened in CPI-food of Malaysia.

Core Inflation

Country	Series	Source	Other
Hong Kong**	CPI excl food&transportation, generated using constant weight	CEIC	Index (2005=100)
Indonesia	CPI excl volatile food and administered prices	Bank Indonesia	Index (2007=100)
Korea	KR: Consumer Price Index: Core, excl. Agricultural Products & Oils: QUART	CEIC	Index (2005=100)
Malaysia*	CPI excl. food&transportation, generated using constant weight (2005-09)	CEIC	Index (2005=100)
Philippines	CPI-Core	CEIC/BSP	Index (2000=100)
Singapore**	CPI excl food&transportation, generated using constant weight	CEIC	Index (2009=100)
Taiwan	CPI excl food & energy	CEIC	Index (2006=100)
Thailand	CPI excl raw food and energy	CEIC	Index (2007=100)

*For Malaysia, there is new classification from based year 2000 to 2005. We connect the data using year on year growth. This new classification makes us cannot exclude fuel because we don't have the weight of 2000 based year.

** We exclude food and transportation because there is no special component of energy or fuel.

World Commodity Prices

	Source	Series
World Oil Price	IFS-IMF	Petroleum: average crude price (Units: US Dollars per Barrel) 00176AAZZF (Source: World)
World Food Price	IFS-IMF	Food (Units: Index Number) 00176EXDZF (2005=100)

GDP, Exchange Rate

	Source	Series
GDP	IFS-IMF. CEIC	<ul style="list-style-type: none"> • Hong Kong: 99B.PSF GDP Vol 2008 Ref., Chained (Units: National Currency) (Scale: Billions) • Indonesia: 99B.PVF GDP AT 2000 Prices (Units: National Currency) (Scale: Billions) • Korea: 99B.PTF GDP AT 2005 Prices (Units: National Currency) (Scale: Billions) • Malaysia: 2005p • Philippines: 99B.PZF GDP Volume 1985 Prices (Units: National Currency) (Scale: Billions) • Singapore: 99B.PVF GDP AT 2000 Prices (Units: National Currency) (Scale: Billions) • Taiwan: TW: Gross Domestic Product (GDP): 2006p • Thailand: 99B.PYF GDP AT 1988 Prices (Units: National Currency) (Scale: Billions)
Exchange rate	IFS-IMF	Nominal (..RH.ZF Market Rate (Units: US Dollars per National Currency) Nominal Effective Exchange Rate - Korea NEER from ULC - Philippines NEER from INS Indonesia and Thailand use NEER of BIS

Appendix 3.2. Unit Root Test

Variables	Augmented Dickey-Fuller Test Result							
	Countries							
	Hong Kong		Indonesia		Korea		Malaysia	
Domestic Food Price	-3.168	**	-5.327	***	-7.757	***	-4.061	***
Domestic Fuel Price	-5.612	***	-6.086	***	-6.125	***	-6.060	***
CPI	-3.011	**	-5.211	***	-7.610	***	-4.732	***
Core	-7.025	***	-4.728	***	-3.854	***	-5.712	***
Output Gap	-2.028		-5.068	***	-4.171	***	-4.030	***
Nominal Exchange Rate	-6.095	***	-6.220	***	-4.337	***	-5.164	***

*** p<0.01 ** p<0.05 * p<0.1

All data are quarter to quarter

All variables are in difference log except for output gap, it is in terms of logarithm of gdp/gdp_hpfilter

Only Hong Kong, Philippines and Singapore's output gap are in terms of difference log given the ADF test results

Variables	Augmented Dickey-Fuller Test Result							
	Countries							
	Philippines		Singapore		Taiwan		Thailand	
Domestic Food Price	-4.851	***	-3.277	**	-9.686	***	-4.637	***
Domestic Fuel Price	-4.385	***	-5.731	***	-6.508	***	-5.624	***
CPI	-4.256	***	-3.663	***	-6.779	***	-5.568	***
Core	-3.097	**	-4.308	***	-3.863	***	-5.780	***
Output Gap	-2.937	*	-2.799	*	-3.725	***	-3.937	***
Nominal Exchange Rate	-3.955	***	-4.688	***	-6.436	***	-4.419	***
World Food Price							-4.938	***
World Oil Price							-4.852	***

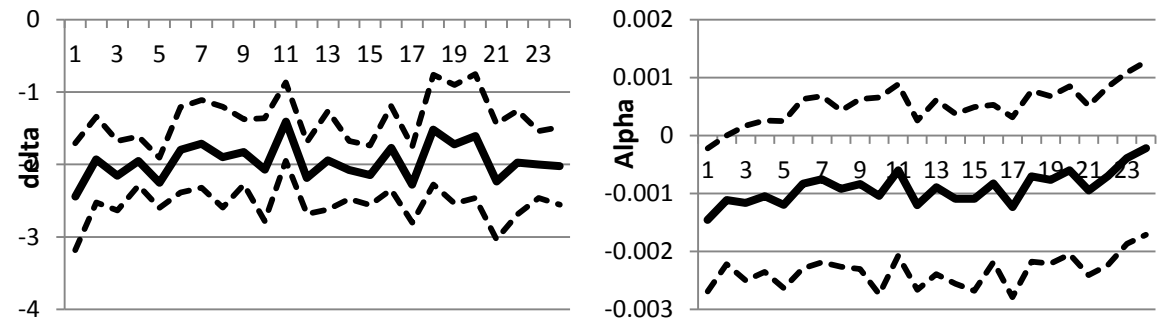
*** p<0.01 ** p<0.05 * p<0.1; all data are quarter to quarter

All variables are in difference log except for the output gap is in terms of logarithm of gdp/gdp_hpfilter

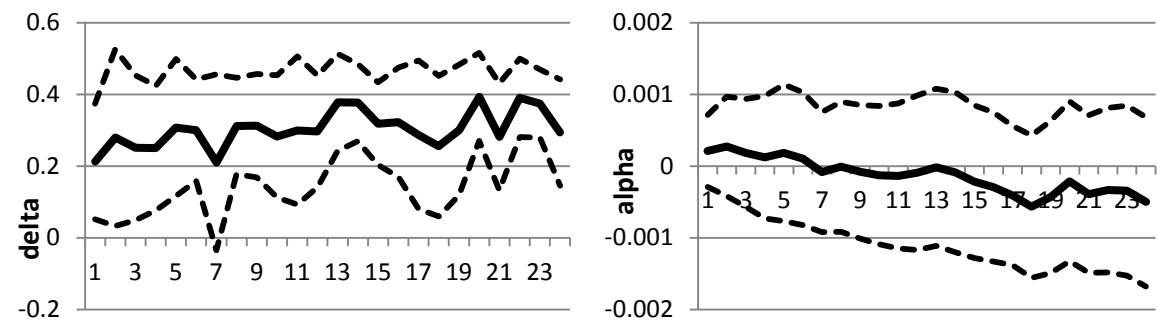
Only Hong Kong, Philippines and Singapore's output gap are in terms of difference log given the ADF test

Appendix 3.3. Alpha and Delta Coefficient for Equation (3.5)

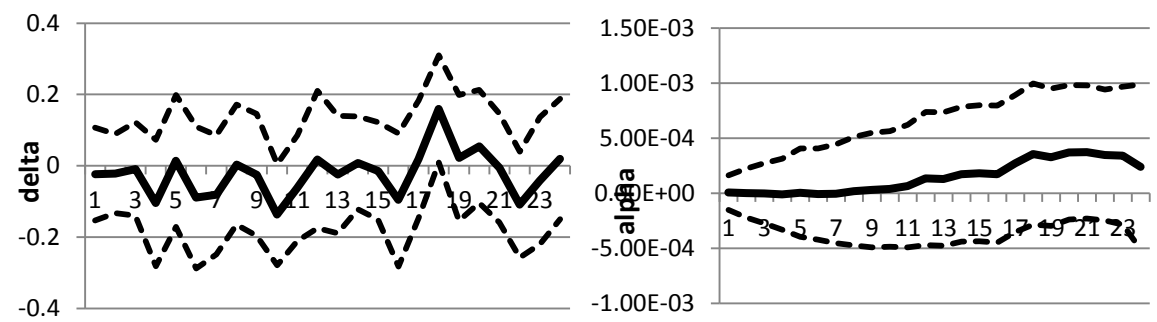
Hong Kong



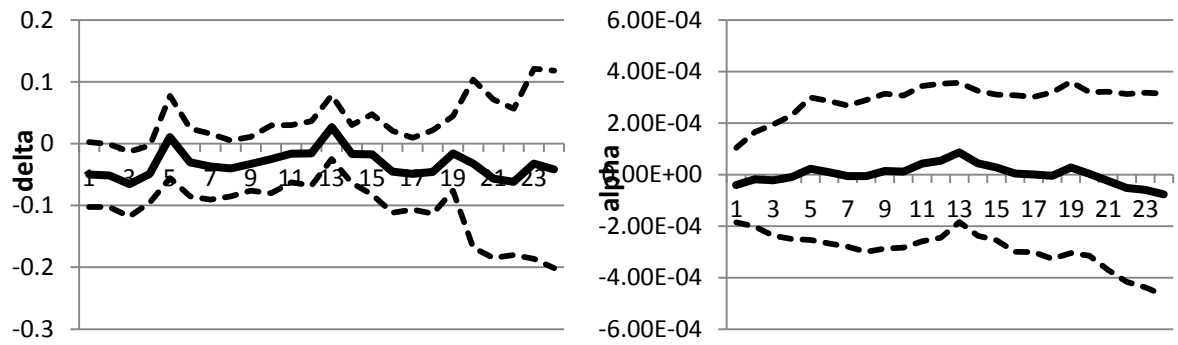
Indonesia



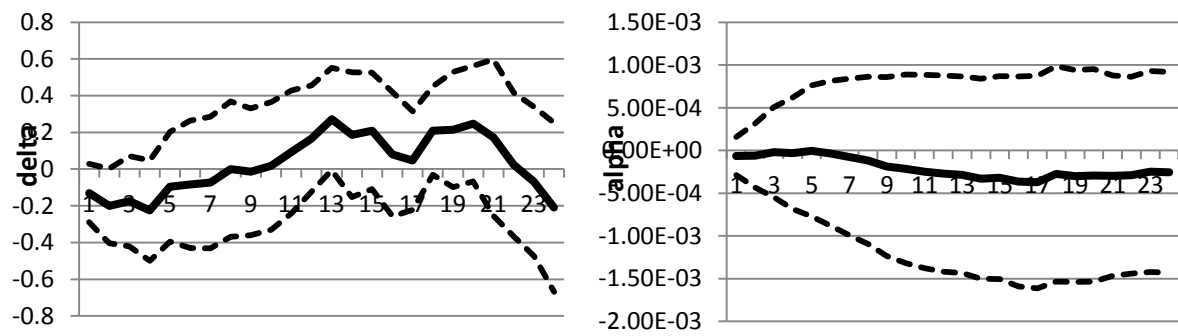
Korea



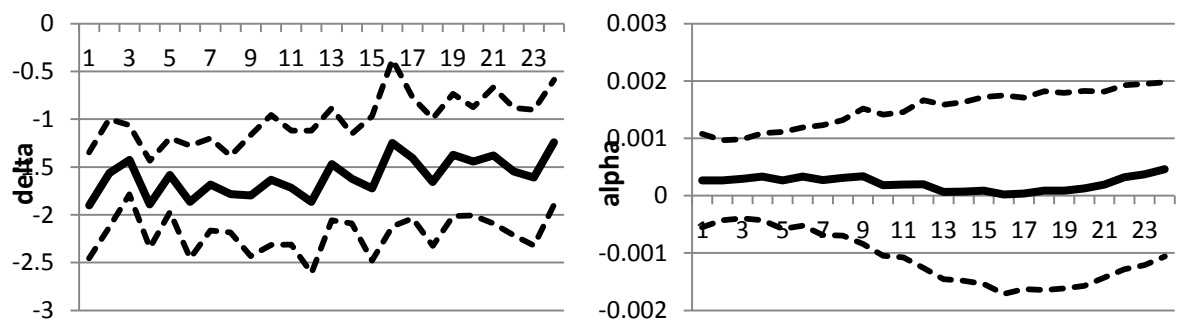
Malaysia



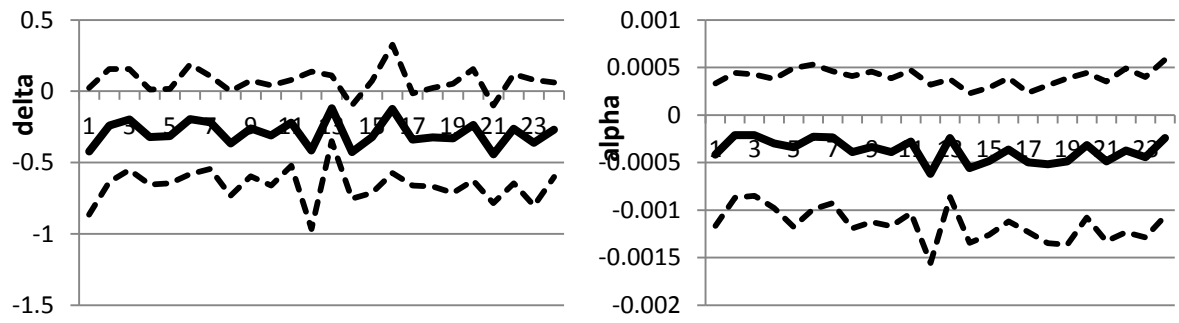
Philippines



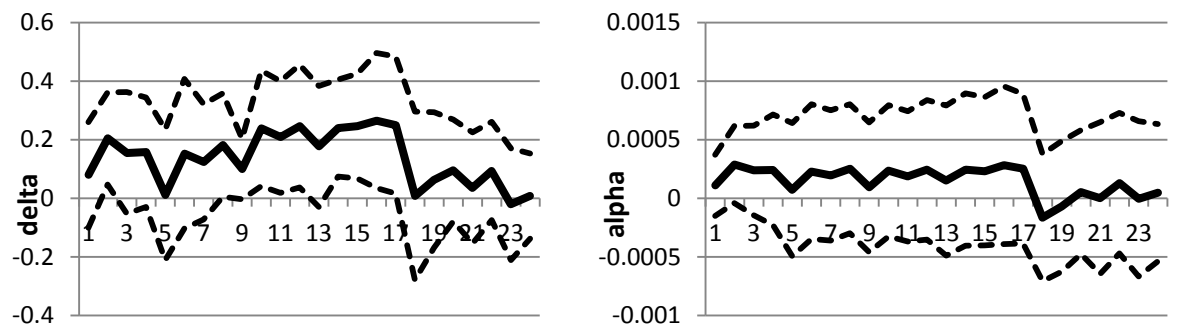
Singapore



Taiwan



Thailand



Appendix 3.4. Estimation Results

The First Pass Through of World Oil Inflation

Variable	Domestic Fuel Inflation			
	Hong Kong	Indonesia	Korea	Malaysia
Constant	0.001 <i>0.003</i>	0.034 ** <i>0.016</i>	0.006 <i>0.004</i>	-0.002 <i>0.009</i>
Domestic Fuel Inflation (-1)	-0.275 ** <i>0.043</i>		-0.337 *** <i>0.085</i>	-0.164 <i>0.116</i>
Domestic Fuel Inflation (-2)	0.137 ** <i>0.044</i>			-0.124 <i>0.130</i>
Domestic Fuel Inflation (-3)				0.178 * <i>0.095</i>
Domestic Fuel Inflation (-4)				
World Oil Inflation	0.261 ** <i>0.038</i>	0.182 ** <i>0.056</i>	0.267 *** <i>0.024</i>	0.103 <i>0.089</i>
World Oil Inflation (-1)				0.103 <i>0.065</i>
World Oil Inflation (-2)				0.130 ** <i>0.058</i>
Adj R ²	0.791	0.039	0.612	0.271

*** p<0.01 ** p<0.05 * p<0.1; Standard Errors are in italics

The First Pass Through of World Oil Inflation (continued)

Variable	Domestic Fuel Inflation			
	Philippines	Singapore	Taiwan	Thailand
Constant	0.004 <i>0.005</i>	-0.002 <i>0.007</i>	0.003 <i>0.005</i>	0.008 <i>0.006</i>
Domestic Fuel Inflation (-1)	-0.141 <i>0.116</i>	-0.484 *** <i>0.099</i>	-0.098 <i>0.157</i>	-0.454 *** <i>0.149</i>
Domestic Fuel Inflation (-2)	0.167 *** <i>0.033</i>		-0.315 ** <i>0.122</i>	
Domestic Fuel Inflation (-3)	0.107 ** <i>0.044</i>		-0.016 <i>0.159</i>	
Domestic Fuel Inflation (-4)			-0.300 * <i>0.160</i>	
World Oil Inflation	0.495 *** <i>0.033</i>	0.946 *** <i>0.048</i>	0.433 *** <i>0.058</i>	0.477 *** <i>0.086</i>
World Oil Inflation (-1)	0.194 *** <i>0.060</i>	0.239 *** <i>0.082</i>	-0.103 *** <i>0.062</i>	
World Oil Inflation (-2)			0.182 ** <i>0.080</i>	
World Oil Inflation (-3)			-0.108 <i>0.074</i>	
World Oil Inflation (-4)			0.169 ** <i>0.075</i>	
Adj R ²	0.875	0.891	0.813	0.692

*** p<0.01 ** p<0.05 * p<0.1; Standard Errors are in italics

The First Pass Through of World Food Inflation

Variable	Domestic Food Inflation				
	Hong Kong	Indonesia	Korea	Malaysia	
Constant	0.001 <i>0.001</i>	0.009 * <i>0.004</i>	0.010 *** <i>0.002</i>	0.001 <i>0.001</i>	
Domestic Food Inflation (-1)	0.234 <i>0.163</i>	0.063 <i>0.163</i>		0.226 ** <i>0.105</i>	
Domestic Food Inflation (-2)	0.515 ** <i>0.169</i>	0.194 ** <i>0.072</i>		0.337 ** <i>0.166</i>	
Domestic Food Inflation (-3)		0.201 ** <i>0.098</i>			
World Food Inflation	0.069 *** <i>0.018</i>	0.128 *** <i>0.033</i>	-0.031 <i>0.029</i>	0.048 <i>0.017</i>	***
World Food Inflation (-1)		0.095 ** <i>0.044</i>	0.004 <i>0.039</i>	0.042 <i>0.025</i>	
World Food Inflation (-2)		0.086 <i>0.063</i>	-0.019 <i>0.041</i>	0.046 *** <i>0.015</i>	
World Food Inflation (-3)		-0.136 *** <i>0.037</i>	0.072 ** <i>0.031</i>		
World Food Inflation (-4)		0.103 ** <i>0.047</i>			
Adj R ²	0.575	0.287	0.096	0.399	

*** p<0.01 ** p<0.05 * p<0.1; Standard Errors are in italics

The First Pass through of World Food Inflation (continued)

Variable	Domestic Food Inflation			
	Philippines	Singapore	Taiwan	Thailand
Constant	0.003 <i>0.004</i>	0.001 <i>0.001</i>	0.004 <i>0.003</i>	0.003 <i>0.002</i>
Domestic Food Inflation (-1)	0.042 <i>0.137</i>	0.351 <i>0.213</i>	-0.445 *** <i>0.124</i>	0.056 <i>0.156</i>
Domestic Food Inflation (-2)	-0.019 <i>0.104</i>	0.308 ** <i>0.144</i>	0.145 <i>0.137</i>	0.383 *** <i>0.087</i>
Domestic Food Inflation (-3)	0.538 ** <i>0.263</i>		0.297 * <i>0.156</i>	
Domestic Food Inflation (-4)				
World Food Inflation	0.072 *** <i>0.021</i>	0.030 ** <i>0.015</i>	0.042 <i>0.057</i>	0.063 *** <i>0.019</i>
World Food Inflation (-1)	0.103 <i>0.078</i>		0.068 * <i>0.040</i>	0.069 *** <i>0.020</i>
World Food Inflation (-2)	0.078 *** <i>0.019</i>			0.070 *** <i>0.024</i>
Adj R ²	0.338	0.377	0.180	0.362

*** p<0.01 ** p<0.05 * p<0.1; Standard Errors are in italics

The Second Pass Through of World Oil and Food Inflation

Variable	Core Inflation							
	Hong Kong		Indonesia		Korea		Malaysia	
Constant	-0.003		0.013	***	0.003	**	0.003	**
	<i>0.003</i>		<i>0.002</i>		<i>0.001</i>		<i>0.001</i>	
Core Inflation (-1)					0.015			
					<i>0.229</i>			
Core Inflation (-2)					0.484	***		
					<i>0.095</i>			
Output Gap	0.243	**	-0.317	**	0.038		-0.035	
	<i>0.105</i>		<i>0.118</i>		<i>0.027</i>		<i>0.057</i>	
Output Gap (-1)	0.356	*			0.139	***		
	<i>0.130</i>				<i>0.031</i>			
Output Gap (-2)					-0.073			
					<i>0.048</i>			
Output Gap (-3)					0.073	**		
					<i>0.031</i>			
Domestic Food Inflation	0.112						0.949	***
	<i>0.641</i>						<i>0.204</i>	
Domestic Food Inflation (-1)	-0.603						-0.362	***
	<i>0.642</i>						<i>0.115</i>	
Domestic Food Inflation (-2)	-0.083						-0.415	**
	<i>0.518</i>						<i>0.162</i>	
Domestic Food Inflation (-3)	1.291	***						
	<i>0.461</i>							
Domestic Food Inflation (-4)								
Domestic Fuel Inflation			-0.010				-0.013	
			<i>0.026</i>				<i>0.019</i>	
Domestic Fuel Inflation (-1)			0.015					
			<i>0.031</i>					
Domestic Fuel Inflation (-2)			0.076	***				
			<i>0.020</i>					
Adj R ²	0.112		0.038		0.527		0.548	

*** p<0.01 ** p<0.05 * p<0.1; Standard Errors are in italics

The Second Pass Through of World Oil and Food Inflation (continued)

Variable	Core Inflation				
	Philippines	Singapore	Taiwan	Thailand	
Constant	0.002 <i>0.002</i>	0.000 <i>0.001</i>	0.001 *** <i>0.000</i>	0.001 <i>0.001</i>	
Core Inflation (-1)	0.414 ** <i>0.161</i>	-0.133 <i>0.169</i>	-0.186 <i>0.123</i>	-0.403 <i>0.361</i>	
Core Inflation (-2)	0.041 <i>0.135</i>	-0.257 ** <i>0.124</i>	-0.077 <i>0.095</i>	0.380 ** <i>0.147</i>	
Core Inflation (-3)	0.359 ** <i>0.164</i>	-0.194 <i>0.127</i>	-0.051 <i>0.108</i>		
Core Inflation (-4)	-0.281 * <i>0.150</i>	-0.577 *** <i>0.147</i>	-0.267 ** <i>0.123</i>		
Output Gap	-0.032 <i>0.035</i>	0.010 <i>0.060</i>	0.082 *** <i>0.013</i>	0.090 * <i>0.046</i>	
Output Gap (-1)	0.133 * <i>0.067</i>			-0.062 <i>0.095</i>	
Output Gap (-2)				-0.091 <i>0.074</i>	
Output Gap (-3)				0.185 ** <i>0.067</i>	
Domestic Food Inflation	0.153 ** <i>0.062</i>	0.258 ** <i>0.097</i>	-0.018 <i>0.019</i>		
Domestic Food Inflation (-1)		0.581 *** <i>0.161</i>	0.043 *** <i>0.012</i>		
Domestic Food Inflation (-2)		0.225 <i>0.142</i>			
Domestic Food Inflation (-3)		0.358 *** <i>0.122</i>			
Domestic Food Inflation (-4)		0.171 * <i>0.089</i>			
Domestic Fuel Inflation	0.029 *** <i>0.009</i>	0.003 <i>0.008</i>	-0.003 <i>-0.704</i>	0.028 * <i>0.015</i>	
Domestic Fuel Inflation (-1)				0.014 <i>0.013</i>	
Domestic Fuel Inflation (-2)				0.039 ** <i>0.015</i>	
Domestic Fuel Inflation (-3)				0.013 <i>0.012</i>	
Domestic Fuel Inflation (-4)				-0.013 ** <i>0.006</i>	
Adj R ²	0.514	0.515	0.641	0.161	

*** p<0.01 ** p<0.05 * p<0.1; Standard Errors are in italics

Chapter 4

The Impact Of World Commodity Price Shocks

4.1. Background and Motivation

In the previous chapter, we found that world oil price as well as world food price shocks have an influence on the movement of domestic prices in eight Asian countries: ASEAN4 and NIE4. These influences are quantified in the form of the first and the second pass through effects on domestic inflation. In terms of first pass through, inflation in both world commodities has a significant effect, and the influence of world oil inflation is the larger of the two. However, the second pass through of oil and food inflation is minimal. The second pass through is measured by the effect of domestic food and fuel inflation on core inflation.

Generally, emerging economies are more vulnerable to increases in world commodity prices than developed ones. The main reason is that emerging economies have a larger share of food in their consumption and are more energy intensive. Furthermore, these countries are thought to have less credible monetary policies than any developed ones (IMF, 2008). For this kind of economy, knowledge about the impact of world commodity price shocks is important from many standpoints, among them the need to inform policy makers. Working forward from the previous chapter, the objective of this chapter is to quantify empirically the influence of world commodity price shock on domestic prices and to examine how the monetary authorities react to these shocks. Specifically, we pose the following questions:

1. What are the main differences in monetary policies conducted in the countries under investigation when facing world commodity price shocks?

2. Given the different economic structures, what is the impact of world commodity price shocks, in particular world oil and food price shocks, on the countries' domestic inflation and other macroeconomic variables?

This chapter answers the above questions using the estimations and simulations of a Dynamic Stochastic General Equilibrium (DSGE) model of four countries in Asia: Indonesia, Korea, Thailand and Philippines. These four countries have been chosen since they have the same monetary policy framework, Inflation Targeting Framework (ITF) and similarities in their economic characteristics. The inclusion of other countries entails a different model structure given the very different structures of their economies and monetary policies. For example, of the other countries in the previous chapter, Hong Kong and Singapore implement a different monetary policy framework. Hong Kong implements the Currency Board System (CBS) and Singapore manages its exchange rate in relation to a basket of currencies. Furthermore, Korea is relatively more developed than the others. Comparing the estimation and simulation results between Korea and the other countries will give a view of the impact of the shocks in these developed and developing countries within Asia.

Recently, DSGE models have not only been developed to evaluate the macroeconomic implications of monetary policy shocks such as inflation persistence (e.g. Christiano et al., 2005), but also to scrutinise phenomena such as commodity price shocks. Regarding this, some DSGE models have been developed, for example by Medina and Soto (2005) and Millard (2011), which investigate the effects of oil price shocks on the economies of Chile and the UK respectively, and observe how these are related to the endogenous policy responses. By using this class of model, not only can the impact of

world commodity price shocks be demonstrated, but also comparisons of the monetary policy conducted during periods of shock can be analysed.

Most of the literature examines oil price shocks. However, this chapter includes world food price shocks in its analysis, widening its scope to the effect of world price shocks using DSGE models. Adding world food price shocks allows comparison of the influence of world food and oil prices on the domestic economy. Most DSGE models in the literature focus solely on oil price (for example Millard, 2011) or food price (for example, Catao and Chang, 2010). Our model, which is a departure from the Gali and Monacelli (2005) model, expands household consumption in terms of food, non-food and fuel and has two sectors: food and non-food. World commodity prices influence the marginal cost faced by these sectors, so this model is able to analyse the impact of both world oil and food commodity price shocks on domestic inflation. These features are different from the existing DSGE models. In terms of its application to empirical analysis, to the best of my knowledge this is the first DSGE model with oil and food prices to analyse the inflation dynamic in four ITF countries (Indonesia, Korea, Philippines and Thailand). These features represent the contribution to the literature.

Furthermore, by employing Bayesian estimation, this paper provides a comparison of how each country conducts its monetary policy during the period of estimation. Even though they adopt the same monetary policy framework, they make different emphases in their monetary policy decisions. We can see which countries have more interest rate inertia, or how far a country takes output and exchange rates into account in deciding its policy rate. In addition, other structural parameters, such as price rigidity and the household preferences of each country, are revealed. Given the different parameters of each country, the responses to the shocks also vary. This chapter provides the impulse

responses of some of the main world commodity price shock variables for each country. Different responses, in terms of magnitude and length, provide a comparative study of the countries under investigation. Up to now, no paper that compares the effect of world commodity price shocks in these emerging Asian countries has used a DSGE model. This is another contribution of this chapter.

The chapter is structured as follows. Section 4.2 describes the model. It explains the behaviour of households, firms, monetary policy and various identities. Section 4.3 discusses the methodology and the data used to estimate the model. The results of the estimation are provided in this section. Section 4.4 explains the simulation results based on two scenarios: world oil and food price shocks. The final section concludes the chapter.

4.2. The Model

The model used to address the above questions is a DSGE model within the New Keynesian theoretical framework. It captures the behaviour of some sectors in a small open economy. The model is largely based on the important small open economy model of Gali and Monacelli (2005). Various modifications enable a closer look at the macroeconomic and policy implications given the world commodity price shocks and the different structures of the economy.

There are three sectors in this model: households, firms and government, represented by its monetary authority. Monopolistic competition is assumed in both the labour and goods markets. The households are representative agents who consume domestic and foreign goods. The utility of the household depends on consumption and labour time. The households also supply labour to the production sectors, where wages are set according to the demand for labour. Given the different skills supplied, the households have monopoly power to set their wages. However, not all households can set their wage in

every period. This chapter follows Calvo's (1983) approach to staggering the distribution of wage rates. In particular, the wage setting of this model follows wage rigidity model as in Erceg et al. (2000).

For the domestic production sector, there are two producers in this model: the non-food and the food sector. The former includes manufacturing and mining sectors. The latter may include the agriculture sector and the food manufacturing sectors. The firms in these two sectors produce domestic goods and have monopolistic power. They set their prices in order to maximise profit, subject to demand for their products. Like the households, prices are staggered and follow Calvo (1983), where a fraction of θ of the firms set their prices according to rule of thumb and the remainder $(1 - \theta)$ based on current optimisation.

Unlike the equations in the households and the firms that are based on microeconomic foundations, the monetary sector in this model is typically rudimentary. This sector is represented by a monetary policy rule, in particular the interest rate rule. Money demand is not modelled explicitly; it is considered as a unit of account, already represented by the interest rate in the policy rule. Below is an explanation of each sector.

4.2.1. Households

The household in this model is a continuum household $j \in [0,1]$ whose utility consists of consumption (C) and leisure ($l = 1 - N$). The household divides its unit of time into labour (N) and leisure (l). Utility increases with consumption and decreases with working time.

$$Max E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t) \quad (4.1)$$

Here, $U(C, N) \equiv \frac{C^{1-\sigma}}{1-\sigma} - \frac{N^{1+\varphi}}{1+\varphi}$ and β is the discount factor. σ and φ are constant coefficients of relative risk of aversion for consumption and for labour respectively. The household also faces an intertemporal budget constraint:

$$P_t C_t + E\{Q_{t,t+1} D_{t+1}\} \leq D_t + W_t N_t \quad (4.2)$$

They earn income from the wage (W) they receive by allocating their time to work (N), and the portfolio (D) they hold at the beginning of time t . In addition to consumption, they leave some portfolio at the end of period t or at the beginning of next period (D_{t+1}). Hence, the portion of the asset portfolio they use to consume in period t is $D_t - E\{Q_{t,t+1} D_{t+1}\}$. $Q_{t,t+1}$ is the stochastic discount factor of one period of nominal yield from the assets held by the household. In this model, we do not explicitly introduce money. The role of money is only for the unit of account. We represent monetary policy in a monetary reaction function in the form of interest rate rule.

Maximising their utility (4.1) subject to the budget constraint (4.2), and differentiating with respect to C_t and D_{t+1} results in the following Euler equations:

$$\beta R_t E_t \left\{ \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) \right\} = 1 \quad (4.3)$$

where $R_t = \frac{1}{E_t\{Q_{t,t+1}\}}$. Equation (4.3) is the Euler equation. After stationarizing the equation and log linearization around its steady state will yield:

$$\tilde{c}_t = E_t(\tilde{c}_{t+1}) + E_t(\tilde{a}_{t+1}) - \frac{1}{\sigma} [\tilde{r}_t - E(\pi_{t+1})] \quad (4.4)$$

where $\pi_t \equiv \tilde{p}_t - \tilde{p}_{t-1}$. Note that expected technology shock appears in this equation because of the process of stationarising the model. As we know, the level for real variables such as consumption are non-stationary. We also have a unit root process of technology;

technology in this model grows positively. We stationarise the model by dividing real variables such as consumption (C) with technology (A), so that the variables are stationary. As a result, consumption is this Euler equation is $c = C/A$, which is stationary. A similar Euler equation can be seen in the models that assume a balanced non-zero growth steady state. With this specification we can use the observable variables themselves as inputs in the estimation, not the variables with filtering. In this chapter the variable in log is represented by small lower case letters, e.g. $y_t = \ln(Y_t)$, and its log deviation around steady state is represented by a small letter with tilde $\tilde{y}_t = \ln(Y_t) - \ln(Y)$.

We enhance the model by splitting the consumption aggregate, not only into domestic and imported goods as in Gali and Monacelli (2005), but also into oil, food and other goods. Expenditure on oil could, for instance, reflect transportation activities; food simply represents food consumption. Food is imported as well as produced domestically. We assume food is also produced domestically since some countries under investigation (such as Thailand) have strong agriculture sectors that supply a large portion of their domestic food consumption. To simplify, we assume that oil is imported. All the countries under investigation rely on oil imports for domestic consumption; none are not important oil exporters¹⁰. By explicitly introducing these two commodities that are imported into the bundle of consumption, the effect of the world commodity price shock on these two goods within the domestic economy can be analysed clearly. Macroeconomic and policy implications may then be drawn. The composite of total consumption is:

$$C_t \equiv \left[(1 - \alpha)^{\frac{1}{\eta}} (C_{h,t})^{\frac{\eta-1}{\eta}} + (\alpha)^{\frac{1}{\eta}} (C_{f,t})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \quad (4.5)$$

¹⁰ Indonesia was a member of the Organization of the Petroleum Exporting Countries (OPEC) but withdrew in 2008 after becoming a net importer.

C_h represents the consumption of domestic goods and C_f is the consumption of foreign goods. The composite of foreign goods consumption consists of oil consumption C_o , food consumption C_{fF} , and the consumption of other foreign goods or non-food goods C_{fM} . All of them are imported from the country $i \in [0,1]$. The composite of foreign good consumption is:

$$C_f \equiv \left[(1 - \alpha_1 - \alpha_2)^{\frac{1}{v}} (C_{fM,t})^{\frac{v-1}{v}} + (\alpha_1)^{\frac{1}{v}} (C_{o,t})^{\frac{v-1}{v}} + (\alpha_2)^{\frac{1}{v}} (C_{fF,t})^{\frac{v-1}{v}} \right]^{\frac{v}{v-1}} \quad (4.6)$$

This division of foreign goods is consistent with the IMF's world commodity price index. This index has two main items: energy or fuel and non-fuel indices. The non-fuel index combines food and non-food. In our model the shocks from world energy prices are translated into oil prices, the shocks from world food prices are translated into food prices, and those of non-food are translated into the price of other foreign goods or foreign non-food goods.

The consumption of domestic goods itself consists of two domestic goods: food (C_{hF}) and non-food goods (C_{hM}). Its composite is as follows:

$$C_h \equiv \left[(1 - \alpha_3)^{\frac{1}{\kappa}} (C_{hM,t})^{\frac{\kappa-1}{\kappa}} + (\alpha_3)^{\frac{1}{\kappa}} (C_{hF,t})^{\frac{\kappa-1}{\kappa}} \right]^{\frac{\kappa}{\kappa-1}} \quad (4.7)$$

The goods consumed, apart from oil, range from $j = 0..1$. Parameters $\alpha, \alpha_1, \alpha_2$, and α_3 relate to preferences for the goods, whereas $\alpha_i \in [0,1]$. α shows the degree of foreign bias in the preferences. This also reflects the degree of openness. α_1 and α_2 show the preference for the oil and food imported respectively. Implicitly, α_2 represents the dependency of the domestic economy on the supply of foreign food. α_3 captures the preferences for the food produced domestically. Parameters η, v, κ are the elasticity of

substitution between components in each bundle of goods consumption. The consumption aggregate is therefore depicted as follows:

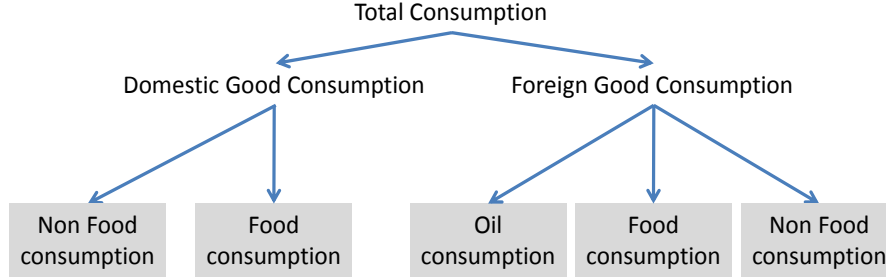


Figure 4.1. Division of Consumption

For any level of consumption, each household maximises utilities from each bundle of consumption subject to its cost. For instance, domestic households' demands for each type j of domestic non-food goods ($C_{hM,t}(j)$) and each type j of domestic foods ($C_{hF,t}(j)$) are derived by minimising the expenditure cost of the consumption of each type j of domestic goods, for both food and non-food. These yield the demand for each type of good.

$$C_{hM,t}(j) = \left(\frac{P_{hM,t}(j)}{P_{hM,t}} \right)^{-\varepsilon} C_{hM,t} \quad (4.8)$$

$$C_{hF,t}(j) = \left(\frac{P_{hF,t}(j)}{P_{hF,t}} \right)^{-\varepsilon_{hF}} C_{hF,t} \quad (4.9)$$

These demands, both by domestic households as well as by foreign ones, will determine the price setting of domestic producers in the two sectors.

We assume the labour market is monopolistically competitive. Even though the labour market in most Asian countries is typically characterised by an abundant supply of labour and relatively weak labour unions, this specification captures the behaviour of skilled labour that is growing in these countries. For the purpose of simplification, we also

assume the labour markets in the non-food and food sectors have an identical demand for labour with skills (j), which is supplied by the households (j). The households will supply differentiated units of labour that are imperfect substitutes; this generates monopoly power. Nominal wage rigidities following Calvo (1983) are introduced. Consequently, the equilibrium condition that equates labour supply and labour demand is replaced by a nominal wage equation. We follow Erceg et al. (2000) in deriving the nominal wage inflation.

Calvo's (1983) model explains the rigidity from the perspective of a price set by firms. It is based on two assumptions: that nominal individual prices are not revised continuously, and that the revision of prices is not conducted simultaneously. A firm revises its prices whenever it gets a signal to do so. The signal emitted in the next period is assumed following a geometric distribution that is independent of the past but similar for all firms and stationary over time. By assuming the law of a large number combined with the continuum of the firms, the probability of receiving that signal can be related to the “number” of firms which set their prices.

Analogously, our model assumes that there is a fraction (θ_W) of households whose wage remains unchanged and another fraction ($1 - \theta_W$) who reset their wage based on optimisation. This fraction is randomly selected. Under the Calvo price setting $W_{t+k}(j) = \bar{W}_t(j)$, the wage in the future ($t+k$) will be set according to the current effective wage or optimal wage with probability $\theta_W^k (k = 0, 1, 2, \dots)$. Given that, the remaining $(1 - \theta_W)$ households perform the optimisation based on the effective wage at the time t (\bar{W}_t). For the future wage ($t+k$), the effective wage will be set with the probability θ_W^k . Consequently, the household's maximisation problem will be maximising utility (4.1) subject to budget constraint (4.2) and demand for labour:

$$N^d_{t+k} \leq \left(\frac{\bar{W}_t}{W_{t+k}} \right)^{-\varepsilon_w} N_{t+k} \quad (4.10)$$

This will yield a first order condition (FOC) with respect to wage:

$$\sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \left\{ C_{t+k}^{-\sigma} P_{t+k}^{-1} N^d_{t+k} \left[\bar{W}_t - \frac{\varepsilon_w}{\varepsilon_w - 1} MRS_{t+k} P_{t+k} \right] \right\} = 0 \quad (4.11)$$

Log linearisation around the steady state will yield

$$\tilde{\bar{w}}_t = (1 - \beta \theta_w) \tilde{m} \tilde{r} s_t + \beta \theta_w E_t \bar{w}_{t+1} \quad (4.12)$$

The wage set by the household is determined by the sequence of expected wage rates and the current marginal rate of substitution between labour and consumption. The combination between the wage generated by optimisation and the wage that does not change is reflected in log linearisation around its steady state of the composite of wage below.

$$\tilde{w}_t = \theta_w \tilde{w}_{t-1} + (1 - \theta_w) \tilde{\bar{w}}_t \quad (4.13)$$

The equations above imply a nominal wage inflation equation of this model as follows:

$$\pi_{w,t} = \beta E_t (\pi_{w,t+1}) + \lambda_w (\tilde{m} \tilde{r} s_t - (\tilde{w}_t - \tilde{p}_t)) \quad (4.14)$$

where $\lambda_w = \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w}$ and the marginal rate of substitution between labour and

consumption is $MRS = -\frac{U_n}{U_c}$.

4.2.2. Firms

There are two types of firms in this model: producers and bundlers. The producers include food and non-food producers. The output of the domestic economy is generated by these two production sectors, which represent the food and non-food sectors in the economy. In line with the GDP composition by sector, the former approximates the

agricultural sector, where most food production occurs; the latter relates to the other sectors. These two are identical: they both produce intermediate goods $i \in [0,1]$, which will be bundled by the producer of the final goods, the bundlers. The producers of intermediate goods have monopolistic power, while the producers of the final goods, or the bundlers, do not. The monopolistic power of the intermediate good producers comes from the differentiated goods they produce, which are imperfect substitutes. They set the price considering the demand for their products. The only difference between the food and non-food producers is the input they use. The food producers use labour (N) and land (L), while the firms in the non-food sectors use labour and oil (O).

We assume food producers behave in a similar way to non-food producers, including their price setting. This assumption is based on the fact that firms in this sector also include processed food producers, and not necessarily raw food producers or agriculture sectors. They also include not only small producers but also large manufacturing companies that produce processed foods that are imperfect substitutes. Given that we assume that they also have monopoly power given the differentiation in their products that are imperfect substitutes. They can set their own prices based on optimisation as well as on rule of thumb, so there will presumably be price rigidity in this sector if it also appears in manufacturing and services. In addition to this, the fact that food prices are administered and controlled, subject to delay in particular rice, also support the assumption of price rigidity in this sector. Furthermore, the governments of the countries under investigation attempt to intervene in the national market to stabilise domestic prices. This prevents domestic food prices from changing frequently or by much. Given this, the movement of food prices tends to mimic the movement of prices in the model with price rigidity.

As regards the Calvo model, we adopt this approach to model price rigidity of the food producers because it is relatively more tractable and mathematically convenient. This model is also adopted by literature that addresses food prices, for example Catao and Chang (2010). For simplification, we also assume that productivity is the same across sectors. In this section we shall discuss only the behaviour of the firms in the non-food sectors; the behaviour of the firms in the food sectors is identical.

The firms in the non-food sectors employ labour supplied by the households. Their production functions are Cobb-Douglas, where oil is a second input in addition to labour. In every period t they minimise their cost of production consisting of wages (W_t) and oil prices ($P_{O,t}$) as follows:

$$\text{Min } (W_t N_t + P_{O,t} O_t) \quad (4.15)$$

subject to their production function:

$$Y_{hM,t} = A_t N_{hM,t}^\phi O_t^{1-\phi} \quad (4.16)$$

The minimisation problem yields the demand for labour by the firms:

$$N_{hM,t} = \frac{1}{A_t} \left(\frac{P_{O,t}}{W_t} \frac{\phi}{1-\phi} \right)^{1-\phi} Y_{hM,t} \quad (4.17)$$

Or in log linearisation around steady state after stationarising yields:

$$\tilde{n}_{hM,t} \approx \tilde{y}_{hM,t} + (1 - \phi)(\tilde{p}_{O,t} - \tilde{w}_t) \quad (4.18)$$

Meanwhile, demand for labour in the food sector is as follows:

$$\tilde{n}_{hF,t} \approx \tilde{y}_{hF,t} + (1 - \phi_L)(\tilde{p}_{L,t} - \tilde{w}_t) \quad (4.19)$$

The total demand for labour is the sum of the labour demands of the two sectors. We assume the ratio of labour demand for the two sectors is equal to the ratio of the output of each sector.

$$\tilde{n}_t \approx \frac{y_{hM}}{y} \tilde{n}_{hM,t} + \frac{y_{hF}}{y} \tilde{n}_{hF,t} \quad (4.20)$$

On the other hand, the demand for oil is:

$$O_t = \frac{1}{A_t} \left(\frac{W_t}{P_{O,t}} \frac{1-\phi}{\phi} \right)^\phi Y_{hM,t} \quad (4.21)$$

The demand for the factors of production implies the real marginal cost of the firms in terms of a domestic non-food price:

$$MC_{hM,t} = \frac{1}{A_t} \frac{1}{P_{hM,t}} P_{O,t}^{1-\phi} W_t^\phi \left(\frac{1}{1-\phi} \right) \left(\frac{1-\phi}{\phi} \right)^\phi \quad (4.22)$$

The approximation of (4.22) by log linearization around its steady state and after stationarising it is:

$$\widetilde{mc}_{hM,t} \approx (1-\phi)\tilde{p}_{O,t} + \phi\tilde{w}_t - \tilde{p}_{hM,t} \quad (4.23)$$

From (4.23), real marginal cost in terms of domestic non-food prices depends on the real oil price and the real wage. The higher these two components, the higher the real marginal cost. For a firm in the food sector, all the equation formations are identical, apart from their input prices: oil in the non-food sector, and land in the food sector. Productivity is assumed to be common in both sectors.

The domestic firms follow Calvo's (1983) staggered price fashion when setting their price. They have monopolistic power and, when allowed to, set their prices to maximise profit, subject to the demand for their product. Prices are staggered. A fraction of θ of the firms set their prices based on the previous ones and another fraction $(1 - \theta_{hM})$

adjust theirs based on optimisation. Under the Calvo setting $P_{hM,t+k}(j) = \bar{P}_{hM,t}(j)$, the future price is based on the current effective price with probability θ_{hM}^k ($k=0,1,2\dots$). The remainder $(1 - \theta_{hM})$ of the firms maximise the current value of their profit based on the effective prices at that time t ($\bar{P}_{hM,t}$). The sequence of their profit, current and future profits will be set based on that price. For the next period $(t+k)$ this effective price will be set with probability θ_{hM}^k . Consequently, the firms will maximise the present value of the sequence of their profit based on this effective price and their nominal marginal cost as follows:

$$\text{Max } \sum_{k=0}^{\infty} \theta_{hM}^k E_t \{ Q_{t,t+k} [Y_{t+k}(j) (\bar{P}_{hM,t} - MC_{t+k}^n)] \} \quad (4.24)$$

subject to the demand for the product from both the domestic and the foreign market.

$$Y_{t+k} \leq \left(\frac{\bar{P}_{hM,t}}{\bar{P}_{hM,t+k}} \right)^{-\varepsilon_{hM}} Y_{t+k}^d \quad (4.25)$$

This maximisation problem yields the price set by the firms:

$$\bar{P}_{hM,t} \sum_{k=0}^{\infty} (\beta \theta_{hM})^k \Gamma_{t+k} = \frac{\varepsilon_{hM}}{(\varepsilon_{hM} - 1)} P_{hM,t-1} \sum_{k=0}^{\infty} (\beta \theta_{hM})^k \Gamma_{t+k} \Pi_{t-1,t+k}^H MC_{t+k} \quad (4.26)$$

where $\Gamma_{t+k} = E_t \left\{ C_{t+k}^{-\sigma} \frac{Y_{t+k}^d}{\bar{P}_{t+k}} \right\}$. Log linearisation of equation (4.6) yield:

$$\tilde{p}_{hM,t} - \tilde{p}_{hM,t-1} \approx \pi_{hM,t} + \beta \theta_{hM} E_t (\tilde{p}_{hM,t+1} - \tilde{p}_{hM,t}) + (1 - \beta \theta) \tilde{m} \tilde{c}_t \quad (4.27)$$

The price is determined by expected inflation and the current marginal cost. The combination between the price generated by optimisation and the price based on the rule of thumb is reflected in the composite:

$$P_{hM,t} = [\theta_{hM} P_{hM,t-1}^{1-\varepsilon_{hM}} + (1 - \theta_{hM}) \bar{P}_{hM,t}^{1-\varepsilon_{hM}}]^{\frac{1}{1-\varepsilon_{hM}}} \quad (4.28)$$

Log linearisation around its steady state, gives

$$\tilde{p}_{hM,t} \approx \theta_{hM} \tilde{p}_{hM,t-1} + (1 - \theta_{hM}) \tilde{\tilde{p}}_{hM,t} \quad (4.29)$$

These equations above will form the New Keynesian Phillips Curve:

$$\pi_{hM,t} = \beta E_t(\pi_{hM,t+1}) + \lambda_{hM} \tilde{m}c_{hM,t} \quad (4.30)$$

where $\lambda_{hM} = \frac{(1-\theta_{hM})(1-\beta\theta_{hM})}{\theta_{hM}}$. We let the real marginal cost appear, instead of the output gap as generally used in other models, to make the transmission of the oil price to the domestic inflation rate clearer. The oil price will influence the cost of production reflected in marginal cost, and the marginal cost influences the price of non-food goods. Eventually, the oil price will influence inflation in this sector too. Analogously, the food producers will also set their prices given their monopoly power. Inflation in the domestic food sector will be determined by the equations below.

$$\pi_{hF,t} = \beta E_t(\pi_{hF,t+1}) + \lambda_{hF} \tilde{m}c_{hF,t} \quad (4.31)$$

$$\tilde{m}c_{hF,t} \approx (1 - \phi_L) \tilde{p}_{L,t} + \phi \tilde{w}_t - \tilde{p}_{hF,t} \quad (4.32)$$

where $\lambda_{hF} = \frac{(1-\theta_{hF})(1-\beta\theta_{hF})}{\theta_{hF}}$. Unlike in the manufacturing sector, the marginal cost in this sector is determined by the real price of land, instead of oil.

The second type of firms, the bundlers, combine goods to make a composite product and assist households in finding the best combination of goods. There are three steps in bundling activities that make the final product ready to be consumed. First, the bundling activities of j type of goods produced by each non-food and food producer into the final goods of each sector. Second, the bundling activities of food and non-food into domestic goods. The third step is the bundling activities of foreign and domestic goods into the final goods. The firms that combine foreign goods with domestic ones buy them from other firms, namely importers. These importers help the bundlers to find the best

combination of three types of foreign goods, namely oil, food and others, to combine into one bundle. All bundling activities are assumed to be costless and need no labour. The bundlers maximise their profit in perfectly competitive markets at each step and yield the following approximations.

$$\tilde{p}_t \approx (1 - \alpha)\tilde{p}_{h,t} + \alpha\tilde{p}_{f,t} \quad (4.33)$$

$$\tilde{p}_{f,t} \approx (1 - \alpha_1 - \alpha_2)\tilde{p}_{fM,t} + \alpha_1\tilde{p}_{o,t} + \alpha_2\tilde{p}_{fF,t} \quad (4.34)$$

$$\tilde{p}_{h,t} \approx (1 - \alpha_3)\tilde{p}_{hM,t} + \alpha_3\tilde{p}_{hF,t} \quad (4.35)$$

Since our focus is on domestic prices, we also evaluate the movement of core and non-core prices. We define the core prices (\tilde{p}_c) as the combination of domestic and imported prices of non-food goods. Meanwhile, the non-core prices (\tilde{p}_{nc}) refers to the combination of food prices, both domestic and imported, and oil price:

$$\tilde{p}_{c,t} \approx (1 - \alpha)(1 - \alpha_3)\tilde{p}_{hM,t} + \alpha(1 - \alpha_1 - \alpha_2)\tilde{p}_{fM,t} \quad (4.36)$$

$$\tilde{p}_{nc,t} \approx (1 - \alpha)\alpha_3\tilde{p}_{hF,t} + \alpha\alpha_1\tilde{p}_{o,t} + \alpha\alpha_2\tilde{p}_{fF,t} \quad (4.37)$$

4.2.3. Identities

In this section several identities are defined to link inflation, the exchange rate, and the terms of trade. The effective terms of trade are defined as the ratio between the import price and the domestic price in domestic currency:

$$S_t = \left(\int_0^1 S_{i,t}^{1-\gamma} di \right)^{\frac{1}{1-\gamma}} = \frac{P_{f,t}}{P_{h,t}} \quad (4.38)$$

Log linearisation around the steady state yields:

$$\tilde{s}_t = \tilde{p}_{f,t} - \tilde{p}_{h,t} \quad (4.39)$$

It is also assumed that the Law of One Price holds in this model, following Gali and Monacelli (2005). Log linearisation around the steady state and integration of all foreign countries yields the foreign goods price index or the import price:

$$\tilde{p}_{f,t} = \tilde{p}_t^* + \tilde{e}_t \quad (4.40)$$

where e_t is the nominal effective exchange rate (the logarithm of the home currency price of foreign exchange) and p_t^* is the log of world price in the foreign currency. Meanwhile, the bilateral real exchange rate is defined by $\Omega_{i,t} = \frac{\varepsilon_{i,t} P_t^i}{P_t}$. Log linearization of this and integration over all foreign countries, yields the real effective exchange rate:

$$\tilde{q}_i = \tilde{e}_t + \tilde{p}_t^* - \tilde{p}_t \quad (4.41)$$

The relationship between the terms of trade and the real interest rate differential is found by assuming a completely integrated international financial market. The price of riskless foreign bonds denominated in a domestic currency in equilibrium is given by $\varepsilon_{i,t}(R_t^i)^{-1} = E_t(Q_{t,t+1}\varepsilon_{i,t+1})$. Combining this with the price of riskless domestic bonds $R_t^{-1} = E_t(Q_{t,t+1})$ gives the uncovered interest parity condition:

$$\tilde{r}_t - \tilde{r}_t^* = E_t(\Delta\tilde{e}_{t+1}) \quad (4.42)$$

The interest rate differential between domestic and foreign countries matches the expected depreciation of the domestic currency. Combining this with the definition of the terms of trade yields:

$$\tilde{s}_t = E_t\left\{\sum_{k=0}^{\infty}[(\tilde{r}_{t+k}^* - \pi_{t+k+1}^*) - (\tilde{r}_{t+k} - \pi_{h,t+k+1})]\right\} \quad (4.43)$$

So the terms of trade depends on the current, and the anticipated future real interest rate differentials.

4.2.4. Equilibrium

Given the two sectors in the domestic economy, there are two equilibria of goods markets: non-food goods and food. Both goods are consumed domestically and are exported, so the equilibrium of the two goods markets is as follows:

$$Y_{hM,t}(j) = C_{hM,t}(j) + \int_0^1 C_{hM,t}^i(j) di \quad (4.44)$$

$$Y_{hF,t}(j) = C_{hF,t}(j) + \int_0^1 C_{hF,t}^i(j) di \quad (4.45)$$

where $Y_{hM,t}$ and $Y_{hF,t}$ are the production of domestic non-food goods and domestic food where the product range is $j = 0..1$. It is assumed that each type of goods j is produced by firm j . The outputs of the domestic firms are consumed domestically ($C_t(j)$) and are exported ($C_t^i(j)$) to country $i \in [0,1]$. The output of the goods, which is also the combined demand of the domestic and foreign economies, is a basis for the NKPC of the goods. Using the first order Taylor approximation, the two demand equations, for the domestic non-food goods and domestic foods are:

$$\tilde{y}_{hM,t} = \kappa(\tilde{p}_{h,t} - \tilde{p}_{hM,t}) + \tilde{c}_t + \left(\alpha\gamma + \alpha\left(\eta - \frac{1}{\sigma}\right)(1 - \alpha) \right) \tilde{s}_t \quad (4.46)$$

$$\tilde{y}_{hF,t} = \kappa(\tilde{p}_{h,t} - \tilde{p}_{hF,t}) + \tilde{c}_t + \left(\alpha\gamma + \alpha\left(\eta - \frac{1}{\sigma}\right)(1 - \alpha) \right) \tilde{s}_t \quad (4.47)$$

These two equations show that domestic output, both for non-food goods and the food sector, depends on a set of variables and deep parameters. These deep parameters include the elasticity of substitution of consumption in household utility and the degree of openness. The variables that influence output are domestic consumption, the relative price between domestic goods prices and each output price, and foreign demand, which is represented by the terms of trade. The real interest rate affects output indirectly through

domestic consumption. As in equation (4.4), domestic consumption depends negatively on the real interest rate. The terms of trade in these equations will be translated into foreign demand and hence export. Increased terms of trade imply real exchange rate depreciation, which boosts competitiveness. Meanwhile, the relative price reflects the interaction between price and output. If a product price is lower than the overall domestic price index, then the demand for that product will increase. The two equations above constitute the aggregate IS curve:

$$\tilde{y}_t = \frac{y_{hM}}{y} \tilde{y}_{hM,t} + \frac{y_{hF}}{y} \tilde{y}_{hF,t} \quad (4.48)$$

Aggregate output is the sum of the outputs of the food and non-food sectors, weighted by their steady state ratio. This ratio reflects the dependence of a country on imported goods. For instance, if the ratio between food sectors to total outputs ($\frac{y_{hF}}{y}$) is small, dependency on foreign food supplies is high. The flow of goods and labour between the agents of the economy is illustrated in figure 4.2. Bundler firms are not included.

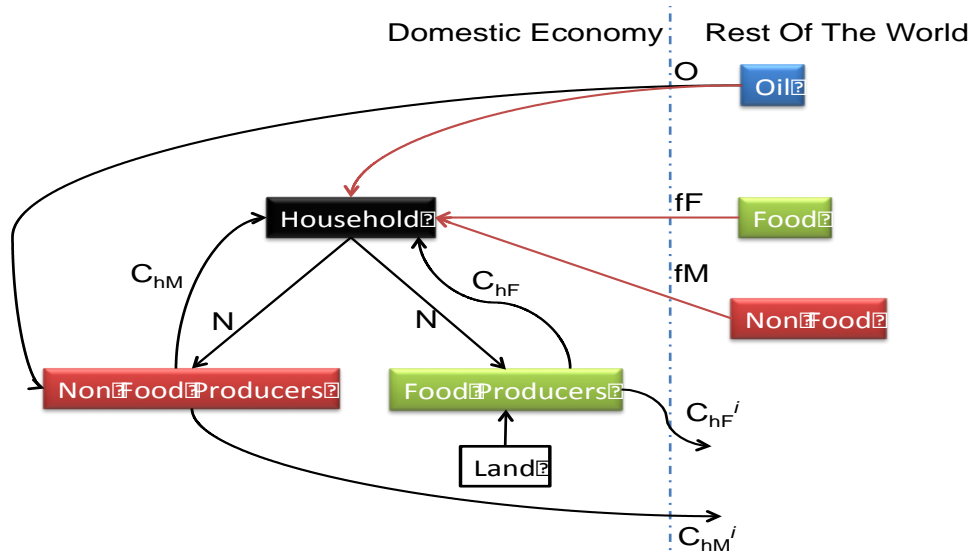


Figure 4.2. Flow of Goods

4.2.5. Monetary Policy

To close the model we follow Lubik and Schorfheide (2007), who employ a simple Taylor rule in which the monetary authority responds to inflation ($\tilde{\pi}_t$), to output (\tilde{y}_t), and to depreciation of the exchange rate ($\tilde{e}_t - \tilde{e}_{t-1}$). By including these three variables, it can be evaluated how monetary policy responds endogenously to the movement of the three variables as a result of world commodity price shock. The reason for including the third variable is to ascertain whether the ITF monetary authorities in the countries under investigation also respond to the exchange rate in setting their policy interest rates. This Taylor rule also assumes the monetary authority sets its interest rate based on the previous interest rate to capture interest rate smoothing. The specification is as follows:

$$\tilde{r}_t = \rho \tilde{r}_{t-1} + (1 - \rho)[\psi_1 \tilde{\pi}_t + \psi_2 \tilde{y}_t + \psi_3 (\Delta \tilde{e}_t)] + e_{r,t} \quad (4.49)$$

Using this specification, we can empirically check on which of the three variables the monetary authority places greater emphasis by evaluating the value of ψ_1, ψ_2, ψ_3 in the estimation for each country.

4.2.6. Shocks

Technology in this model follows a unit root process as follows:

$$\ln A_t = \ln A_{t-1} + \varepsilon_{A,t} \quad (4.50)$$

where A_t is the exogenous technological process; this means the level of technology is non-stationary. Its growth rate is $\varepsilon_{A,t} = \Delta \ln A_t$ and follows an $AR(1)$ process, $\varepsilon_{A,t} = \rho \varepsilon_{A,t-1} + e_{a,t}$ and $e_{a,t}$ is white noise. In this model we have ten shocks which influence the variables in the economy. The six domestic shocks are productivity shocks (e_a), domestic interest rate shocks (e_r), price of land shocks (e_L), and three shocks associated with the import prices of food, non-food, and oil (e_{hf}, e_{hm}, e_{ho}). We can interpret shock

(e_L) as an influence on the prices of non production factors other than labour ones. The import price shocks (e_{hf}, e_{hm}, e_{ho}) can be interpreted as factors that influence the import prices of food, non-food, and oil, such as actions taken by the government to dampen world price shocks; for example, subsidies, tax or other shocks related to import prices. In addition, there are four foreign shocks: world oil price shocks (e_o), world food price shocks (e_{ff}), world non-food price shocks (e_{fM}), and foreign interest rate shocks (e_{r*}).

As with the technological process, some variables related to these shocks have growth rates that follow an $AR(1)$ process, and exerts a permanent or persistent effect. These shocks are price of land shocks (e_L), world oil price shocks (e_o), world food price shocks (e_{ff}), world non-food price shocks (e_{fM}) and foreign interest rate shocks (e_{r*}). Other shocks are white noise: import price shocks (e_{hf}, e_{hm}, e_{ho}) and domestic interest rate shocks (e_r).

We shall focus on the impact of world oil and food price shocks. Overall, the impact of world price shocks will be transmitted to the domestic economy and will affect the behaviour of the agents in that economy. World price shocks will influence the decisions of the agents, for instance household consumption and firm production. The monetary authority will respond to the changes in the economic variables as a result of the changes in the agents' behaviour.

As we have a unit root process for the technology, we stationarise the model following Justiniano et al. (2010) and Adjemian and Julliard (2009) and perform log linearisation to generate a linear approximation for the model. This approach gives equations that reflect the behaviour of each variable around its steady state, as already explained in the previous section. This set of equations will be put into a Dynare program running under MatLab to perform the estimations and simulations required to obtain the

impulse responses. The complete derivation of the model, including its stationary version, its steady state, and its log linear approximation around its steady state are provided in Appendix 4.1.

4.3. Estimation Methodology

There are many approaches to estimating a DSGE model. Geweke (2007) gives these DSGE models three econometric interpretations: weak, strong and minimal, according to the relationship between the DSGE models and the observed data. Weak econometric interpretation includes the work of Kydland and Prescott (1982), whose calibration for some parameters is based on previous studies and common knowledge. The remaining parameters reflect close matches between the observed data and the model generated data, so that the model can replicate some selected moments found in the observed data. Another weak approach is to match the impulse responses of a particular structural VAR with the model itself (see for example Christiano and Eichenbaum, 1990). This also involves General Method of Moments (GMM) estimation.

The classical maximum likelihood estimation (e.g. Ireland, 2001) is a strong econometric interpretation approach, while the Bayesian maximum likelihood estimation is classified as a minimal econometric interpretation approach. The latter technique was first conducted by De Jong et al. (2000) and was followed by Smets and Wouters (2003). Both the classical and Bayesian maximum likelihood estimations are based on the specification of the probabilistic structure of the model that generates the likelihood function. They are based on a combination of parameters, so the data generated by the model are the most likely, given the observed data. Unlike classical maximum likelihood estimations, Bayesian estimations use additional information or priors. This is the calibration part of Bayesian estimations. Given the prior, Bayesian estimations place limitations based on

other research results, common knowledge and even the subjective opinion of the modeller. The combination of priors and maximum likelihood given by the data will generate a set of posteriors for the parameters. In short, Bayesian estimations seek the distribution of the model parameters based on the priors and the observed data. Some other advantages of Bayesian estimations are recorded in Griffoli (2007). The priors act as weights in the estimation process. So the posterior distribution is less likely to converge to strange points defined by the local maxima of the likelihood function. Including shocks in the estimation can also reduce the model misspecifications that often emerge. These shocks behave like measurement errors in structural equations. Based on these considerations, we use the Bayesian methodology to estimate this model.

4.3.1. Bayesian Estimation

Before estimating a DSGE model, we need to know the procedure required to reach the solutions, given the estimated parameters. To begin, the linearised DSGE system is rewritten in a matrix form:

$$\mathbf{B} \begin{bmatrix} \mathbf{z}_{t+1} \\ E_t[\mathbf{x}_{t+1}] \end{bmatrix} = \mathbf{A} \begin{bmatrix} \mathbf{z}_t \\ \mathbf{x}_t \end{bmatrix} + \mathbf{G}\epsilon_t \quad (4.51)$$

where \mathbf{z}_t is an $n \times 1$ vector of the predetermined variables and $E_t[\mathbf{x}_{t+1}]$ is an $m \times 1$ vector of the jump variables with endogenous expectations of their forward-looking values. The values of the predetermined variables at $t+1$ do not depend on the shocks at $t+1$, while the values of jump variables do. \mathbf{B} , \mathbf{A} , and \mathbf{G} are matrices of coefficients in the model. These coefficients are often a combination of deep parameters.

The solution to the above matrix follows the Blanchard and Kahn (1980) approach, which is commonly used in solving the model under rational expectations. The matrix system is converted into

$$\begin{bmatrix} \mathbf{z}_{t+1} \\ E_t[\mathbf{x}_{t+1}] \end{bmatrix} = \mathbf{B}^{-1}\mathbf{A} \begin{bmatrix} \mathbf{z}_t \\ \mathbf{x}_t \end{bmatrix} + \mathbf{B}^{-1}\mathbf{G}\epsilon_t \quad (4.52)$$

Matrix $\mathbf{Z} = \mathbf{B}^{-1}\mathbf{A}$ can be decomposed into $\mathbf{Z} = \mathbf{M}\mathbf{\Lambda}\mathbf{M}^{-1}$ where $\mathbf{\Lambda}$ is a diagonal matrix whose components are the eigenvalues of the matrix \mathbf{Z} . Meanwhile, \mathbf{M} is a matrix of its Eigen vector. The matrix $\mathbf{\Lambda}$ is reordered from the smallest to the largest eigenvalue to become $\bar{\mathbf{\Lambda}}$. The matrix \mathbf{M} is also reordered to be $\bar{\mathbf{M}}$ so that each element in the eigenvector is associated with its eigenvalues in $\bar{\mathbf{\Lambda}}$.

$$\begin{bmatrix} \mathbf{z}_{t+1} \\ E_t[\mathbf{x}_{t+1}] \end{bmatrix} = \bar{\mathbf{M}}\bar{\mathbf{\Lambda}}\bar{\mathbf{M}}^{-1} \begin{bmatrix} \mathbf{z}_t \\ \mathbf{x}_t \end{bmatrix} + \mathbf{B}^{-1}\mathbf{G}\epsilon_t \quad (4.53)$$

The solution to this system exists if the number of eigenvalues that have absolute values greater than one are equal to the number of jump variables (m). By pre-multiplying the system in equation (4.53) by $\bar{\mathbf{M}}^{-1}$, the system is converted into:

$$\begin{bmatrix} \hat{\mathbf{z}}_{t+1} \\ E_t[\hat{\mathbf{x}}_{t+1}] \end{bmatrix} = \begin{bmatrix} \hat{\mathbf{\Lambda}}_{11} & \mathbf{0} \\ \mathbf{0} & \hat{\mathbf{\Lambda}}_{22} \end{bmatrix} \begin{bmatrix} \hat{\mathbf{z}}_t \\ \hat{\mathbf{x}}_t \end{bmatrix} + \begin{bmatrix} \hat{\mathbf{G}}_1 \\ \hat{\mathbf{G}}_2 \end{bmatrix} \epsilon_t \quad (4.54)$$

where the variables with a hat are the multiplication of the variables by $\bar{\mathbf{M}}^{-1}$. The solution strategy begins by solving the unstable transformed equation $E_t[\hat{\mathbf{x}}_{t+1}]$, then the stable one $\hat{\mathbf{z}}_{t+1}$, and finally translating back the transformed variables into the original \mathbf{x}_t and \mathbf{z}_t vectors. All the variables, including the forward-looking or jump variables, are now functions of the predetermined variables and the expectations operator drops out:

$$\begin{bmatrix} \mathbf{z}_{t+1} \\ \mathbf{x}_{t+1} \end{bmatrix} = \begin{bmatrix} \tilde{\mathbf{A}}_{11} & \mathbf{0} \\ \tilde{\mathbf{A}}_{12} & \mathbf{0} \end{bmatrix} \begin{bmatrix} \mathbf{z}_t \\ \mathbf{x}_t \end{bmatrix} + \begin{bmatrix} \tilde{\mathbf{G}}_1 \\ \tilde{\mathbf{G}}_2 \end{bmatrix} \epsilon_t \quad (4.55)$$

There is a special case where matrix \mathbf{B} is non-invertible. If so, there is another way of decomposing the matrices \mathbf{B} and \mathbf{A} . This technique is called the Schur or QZ decomposition (Klein, 2000; Sims, 2002). The matrix system (4.51) is re-written as:

$$\mathbf{QTZ}' \begin{bmatrix} \mathbf{z}_{t+1} \\ E_t \mathbf{x}_{t+1} \end{bmatrix} = \mathbf{QSZ}' \begin{bmatrix} \mathbf{z}_t \\ \mathbf{x}_t \end{bmatrix} + \mathbf{G}\epsilon_t \quad (4.56)$$

where \mathbf{Q} and \mathbf{Z} have a special property: $\mathbf{QQ}' = \mathbf{Q}'\mathbf{Q} = \mathbf{I} = \mathbf{ZZ}' = \mathbf{Z}'\mathbf{Z}$. \mathbf{T} and \mathbf{S} are the upper triangular matrices and the eigenvalues of the system are $\lambda_{ii} = \frac{s_{ii}}{t_{ii}}$. s_{ii} and t_{ii} are the diagonal elements of matrices \mathbf{S} and \mathbf{T} respectively. The next step is to multiply both sides with \mathbf{Q}' , which removes \mathbf{Q} given its property. Other steps are as in Blanchard and Kahn (1980).

From equation (4.55), the model can be used to carry out simulations if the deep parameters within the matrices $\begin{bmatrix} \tilde{\mathbf{A}}_{11} & \mathbf{0} \\ \tilde{\mathbf{A}}_{12} & \mathbf{0} \end{bmatrix}$ and $\begin{bmatrix} \tilde{\mathbf{G}}_1 \\ \tilde{\mathbf{G}}_2 \end{bmatrix}$ are known. To do this, we use the Dynare program to estimate these deep parameters using Bayesian techniques. Dynare converts the linear equation system above into a state-space model similar to the Kalman filter representation by adding a measurement equation. The latter equation associates the model with the observable variables:

$$\begin{bmatrix} \mathbf{z}_{t+1} \\ \mathbf{x}_{t+1} \end{bmatrix} = \begin{bmatrix} \tilde{\mathbf{A}}_{11} & \mathbf{0} \\ \tilde{\mathbf{A}}_{12} & \mathbf{0} \end{bmatrix} \begin{bmatrix} \mathbf{z}_t \\ \mathbf{x}_t \end{bmatrix} + \begin{bmatrix} \tilde{\mathbf{G}}_1 \\ \tilde{\mathbf{G}}_2 \end{bmatrix} \epsilon_t \quad (4.57)$$

$$\mathbf{y}_t = \mathbf{C} \begin{bmatrix} \mathbf{z}_t \\ \mathbf{x}_t \end{bmatrix} + \mathbf{D}\eta_t \quad (4.58)$$

where \mathbf{y}_t is the matrix of observable variables. The matrix systems in (4.57) and (4.58) represent the transition equation and the measurement equation respectively as in a state-space model. We choose observable variables y_t to be incorporated in the model.

Dynare then estimates the likelihood function of the model using the Kalman filter. From the recursion of the Kalman filter, the log likelihood can be derived. The combination of this log likelihood function with the prior, yields the log likelihood of the posterior:

$$\ln \mathcal{K}(\theta|y_T, \mathcal{A}) = \ln \mathcal{L}(\theta|y_T, \mathcal{A}) + \ln p(\theta|\mathcal{A}) \quad (4.59)$$

The first term of the right hand side comes from the Kalman filter recursion, which is the log likelihood function. This describes the density of the observed data given the parameters and the model. The second term is the prior. The left hand side of equation (4.59) is the log likelihood of the posterior conditional on the observed data until period T and model \mathcal{A} . Because the distribution of the posterior is a non-linear and complicated function of the deep parameters, an analytical solution is unlikely. Dynare uses a Monte Carlo Markov Chain (MCMC) sampling method; in particular, the Random Walk Metropolis Hasting. See, for example, Koop (2007) for an explanation of this method. Briefly, the algorithm for it is as follows:

1. Choose a starting value of θ_0 . Then draw the sample of each parameter θ_{i+1} from the proposal distribution. This proposed distribution of the posterior is $N(\theta, c^2 \Sigma)$ where Σ is the covariance matrix.
2. θ_{i+1} is a candidate for θ^* with probability $q(\theta^*/\theta_{i+1})$ and θ_i is a candidate for θ^* with probability $1-q(\theta^*/\theta_{i+1})$. Where $q(\theta_{i+1}|\theta_i) = \min \left[1, \frac{P(\theta^*|y_T)}{P(\theta_i|y_T)} \right]$ is the acceptance ratio.

This ratio compares the posterior given the candidate parameters θ^* to the posterior with the current parameters.

3. If $P(\theta^*|y_T) > P(\theta_i|y_T)$ or $q(\theta_{i+1}|\theta_i) = 1$ then a new element is included. If not, then move to the new candidate parameter using a random walk specification: $\theta^* = \theta_i + \varepsilon$ with $E[\varepsilon] = 0$
 4. Steps 2-3 are repeated until the acceptance rate is around 0.25 as the rule of thumb. In practice, this acceptance ratio can be reached by setting the c in the covariance matrix.
- To reduce the influence of the initial values θ_0 , some initial draws should be discarded.

Dynare has a function to check convergence of these MCMC processes based on Brooks and Gelman (1998). It compares the variance between sequences or blocks (\hat{B}), and those within the replication (\hat{W}) in the MCMC process. Convergence is attained when the within variance (\hat{W}) is stable and the between variance (\hat{B}) is close to zero after a sufficient number of replications. The results of this Bayesian estimation are in the form of a distribution for each parameter. From these distributions, we use their means as the estimators of each parameter in the model.

4.3.2. Calibration and Choice of Prior

In addition to the estimated parameters, some parameters are not estimated. We pick a value for the discount factor (β) equal to 0.99, which is commonly used in other DSGE models. It implies approximately a four percent annual riskless real return in the steady state. We calibrate the degree of openness or foreign bias preference (α) from the country's average ratio of imports to GDP. For the food preference parameter (α_3) in domestic good consumption, the ideal the proxy would be the ratio of domestic food expenditure to domestic goods expenditure. However, these data are not available. So we use the ratio of food expenditure to total consumption expenditure. This parameter is also equal to the ratio of the food sector ($\frac{y_{hF}}{y}$) and might be not an ideal or precise measurement of the food supply in a country. Similarly, for the dependence on a foreign food supply (α_2) in foreign goods consumption, the ideal proxy would be foreign food consumption to foreign goods consumption. These data are not available either. So we proxy it with the ratio of food imported to food consumed.

Other calibrations are related to the foreign shocks. As mentioned previously, we model the shocks as an $AR(1)$ model. With the AR model, the shocks will have permanent

or persistent effects, with persistence captured by the parameter of the AR model. These parameters are taken from the estimation of related variables with the $AR(1)$ specification. For instance, we fit an $AR(1)$ process to quarterly world oil and food inflation to approximate the parameter in the $AR(1)$ model of the world price shocks. All countries experience the same foreign shocks. So these parameter values and their standard error are common across countries.

Table 4.1. Predetermined Parameters

Parameters	Country				Approximated by
	Indonesia	Korea	Philippines	Thailand	
Discount factor (β)	0.99	0.99	0.99	0.99	Equal to 1% real interest rate (quarterly)
Degree of openness (α)	0.27	0.83	0.48	0.64	Ratio of imports to GDP
Foreign food pref in foreign good consumption (α_2)	0.05	0.16	0.1	0.16	Ratio of imported food to food consumption
Domestic food preference in domestic good consumption (α_3)	0.49	0.14	0.53	0.2	Ratio of food consumption to private consumption
The inverse elasticity of labour supply (φ)	3	3	3	3	Gali and Monacelli (2005)
Coefficient of technology AR(1) model (ρ_a)	0.8	0.5	0.7	0.7	AR(1) estimation of real GDP
Coefficient of world oil price AR(1) model (ρ_o)	0.3	0.3	0.3	0.3	AR(1) estimation of world oil price
Standard error of world oil price (σ_o)	0.14	0.14	0.14	0.14	AR(1) estimation of world oil price
Coefficient of world food price AR(1) model (ρ_{ff})	0.24	0.24	0.24	0.24	AR(1) estimation of world food price
Standard error of world food price (σ_{ff})	0.07	0.07	0.07	0.07	AR(1) estimation of world food price
Coeff. of world non-food price AR(1) model (ρ_{fm})	0.5	0.5	0.5	0.5	AR(1) estimation of world non-food price
Standard error of world non food price (σ_{fm})	0.08	0.08	0.08	0.08	AR(1) estimation of world non-food price
Coeff. of foreign interest rate AR(1) model (ρ_{r*})	0.6	0.6	0.6	0.6	AR(1) estimation of foreign interest rate
Standard error of foreign interest rate (σ_{r*})	0.44	0.44	0.44	0.44	AR(1) estimation of foreign interest rate

The predetermined parameters above also demonstrate differences across countries. Korea that can be classified as a developed country has a higher degree of openness (α). It is shown that Thailand and Korea's households have high foreign food preferences (α_2). The households in developing countries, in particular in Indonesia and the Philippines, are also confirmed as having higher preferences for domestic food that is recorded on the approximation of domestic food preference (α_3). It accords with the notion that food consumption in developing countries has higher budget share than in developed countries. The difference from the other two countries is that households in Indonesia and Philippines prefer their domestic food to imported food. Note, in steady state this parameter is equal to the ratio of food sector ($\frac{y_{hF}}{y}$).

For the estimated parameters, we choose the prior means of the deep parameters from various sources. These involve the estimation results of previous studies, and making assumptions if we do not have any knowledge about them. Most previous studies are related to developed countries. Based on a belief that the structural parameters for the economic agent are broadly similar across economies for both developed and developing economies, we use these parameters as our priors. We mainly follow the priors taken from Millard (2011) for the UK economy, Gali Monacelli's (2005) calibration for a small open economy, and Lubik and Schorfheide (2007) who estimate their model on Australia, New Zealand, Canada, and the UK. For instance, for the priors of the parameters in the monetary policy rule we adopt Lubik and Schorfheide (2007). Other priors are based on assumptions. For example, the parameter for labour share we assume a moderate value such as 0.5 since we lack of knowledge about them. We expect the data will give us knowledge about the value by including them in the estimation.

In terms of prior means, these parameters do not differ across countries. However, eventually we let the data of a specific country lead the prior to the “right” parameters of the model. Hence all parameters of the countries end up different. Below are the prior means we choose to estimate the model.

Table 4.2. Prior for Parameters

Parameter	Prior Mean	Distribution Std. Dev	Description	Approximated by
α_1	0.33	Beta, 0.2	Foreign oil (fuel) preferences of household	Assumption
σ	1.55	Normal, 0.198	The inverse elasticity of inter temporal substitution or coefficient relative risk of aversion	Millard (2011).
η	0.5	Beta, 0.2	Elasticity of substitution between domestic and foreign good in household bundle of consumption	Assumption
κ	0.5	Beta, 0.2	Elasticity of substitution between food and non food in household bundle of consumption	Assumption
γ	1	Gamma, 0.2	Elasticity of substitution among imported goods from foreign countries i	Gali & Monacelli (2005)
ϕ	0.5	Beta, 0.2	Labour share in manufacturing (non food) production function	Assumption
ϕ_L	0.5	Beta, 0.2	Labour share in food producer production function	Assumption
θ_{hM}	0.5	Beta, 0.2	Prob. of a manufacturer having to set price at its previous level	Assumption
θ_{hF}	0.5	Beta, 0.2	Probability of a food producer having to set price at its previous level	Assumption
θ_w	0.5	Beta, 0.1	Probability of a household having to set wage at its previous level	Assumption
ρ	0.5	Beta, 0.2	Coefficient of interest rate inertia in policy rule	Lubik Schorfheide (2007)
ψ_1	1.5	Gamma, 0.13	Coefficient of inflation in policy rule	Lubik Schorfheide (2007)
ψ_2	0.25	Gamma, 0.13	Coefficient of output in policy rule	Lubik Schorfheide (2007)

Parameter	Prior Mean	Distribution Std. Dev	Description	Approximated by
ψ_3	0.25	Gamma, 0.13	Coefficient of exchange rate in policy rule	Lubik Schorfheide (2007)
ρ_L	0.5	Beta, 0.2	Coefficient of AR(1) in land price shock	Assumption

4.3.3. Data

Bayesian estimation requires data to generate the posteriors. Since we have six shocks to be estimated, we use six variables in the model that are relevant and related to our main concern: the impact of world commodity prices in the domestic economy, in particular the domestic prices. For all countries we use the data for consumer price index (CPI), real gross domestic product (GDP) per capita, real consumption per capita, domestic food price index, domestic fuel price index, and the nominal effective exchange rate (NEER).

CPI, GDP, and consumption are used as representatives of the overall macroeconomic variables. A nominal effective exchange rate is used to illuminate the interaction between the domestic economy and the rest of the world. We include different type of domestic prices because our main concern is the domestic prices. In particular, we include domestic food prices and fuel prices since they are closely related to the impact of the shocks: world food and oil price shocks.

For domestic fuel and food price we use each country's CPI components for fuel and food. For the domestic food price, there is a special component of food in CPI. For domestic fuel price, there is no special component of CPI for fuel. We proxy this with the fuel component of CPI transportation, for Korea and Philippines. For Indonesia and Thailand, we use the price of gasoline and the non-core energy price respectively. The

sources of data are IFS-IMF, Bank for International Settlement (BIS), CEIC, and Central Bank of each country.

We use the period of 2000Q1 – 2010Q1, as in the approximation of the predetermined parameters above. The main reason is to focus on the effects of recent world commodity shocks. Another consideration is the potential structural break given the Asian financial crisis before 2000. Had we included longer periods of data, the problem of identifying breaks would have greatly complicated the estimation.

4.4. Estimation Results

Based on the Bayesian estimation, we get the distribution of the posterior of each parameter. We use the mean of the posterior distribution as the estimator of the deep parameters in this model. Below is the result of the estimation in terms of posterior mean and ninety percent confidence interval.

Table 4.3. Posterior Means and Ninety Percent Confidence Intervals for Parameters

Parameter	Indonesia		Korea		Philippines		Thailand	
	Post. Mean	Conf. Interval	Post. Mean	Conf. Interval	Post. Mean	Conf. Interval	Post. Mean	Conf. Interval
α_1	0.24	[0.12, 0.38]	0.32	[0.20, 0.41]	0.31	[0.22, 0.39]	0.39	[0.33, 0.46]
σ	1.73	[1.42, 2.04]	1.65	[1.33, 1.97]	1.66	[1.34, 1.96]	1.68	[1.38, 1.97]
η	0.45	[0.27, 0.62]	0.45	[0.13, 0.77]	0.49	[0.22, 0.75]	0.39	[0.10, 0.66]
κ	0.48	[0.16, 0.80]	0.49	[0.16, 0.81]	0.48	[0.16, 0.81]	0.48	[0.16, 0.80]
γ	0.99	[0.68, 1.30]	0.80	[0.58, 1.02]	0.98	[0.71, 1.24]	0.82	[0.62, 1.02]
ϕ	0.34	[0.10, 0.57]	0.28	[0.08, 0.48]	0.30	[0.08, 0.51]	0.19	[0.04, 0.34]
ϕ_L	0.61	[0.42, 0.80]	0.39	[0.14, 0.63]	0.50	[0.30, 0.70]	0.44	[0.18, 0.71]
θ_{hM}	0.98	[0.96, 0.99]	0.94	[0.89, 0.99]	0.98	[0.97, 1.00]	0.98	[0.96, 1.00]
θ_{hF}	0.18	[0.04, 0.31]	0.10	[0.03, 0.18]	0.16	[0.03, 0.28]	0.16	[0.04, 0.27]
θ_w	0.42	[0.27, 0.58]	0.58	[0.41, 0.74]	0.40	[0.25, 0.55]	0.48	[0.31, 0.64]
ρ	0.28	[0.08, 0.47]	0.05	[0.005, 0.10]	0.08	[0.01, 0.16]	0.06	[0.005, 0.11]
ψ_1	1.70	[1.47, 1.94]	1.93	[1.66, 2.20]	1.88	[1.63, 2.12]	1.92	[1.68, 2.16]
ψ_2	0.39	[0.13, 0.65]	0.34	[0.03, 0.47]	0.33	[0.11, 0.54]	0.29	[0.10, 0.49]
ψ_3	0.13	[0.06, 0.20]	0.20	[0.10, 0.30]	0.39	[0.15, 0.63]	0.40	[0.18, 0.62]

Parameter	Indonesia		Korea		Philippines		Thailand	
	Post. Mean	Conf. Interval	Post. Mean	Conf. Interval	Post. Mean	Conf. Interval	Post. Mean	Conf. Interval
ρ_L	0.16	[0.03, 0.27]	0.12	[0.02, 0.21]	0.18	[0.04, 0.31]	0.33	[0.08, 0.56]
e_L	0.08	[0.03, 0.13]	0.18	[0.08, 0.29]	0.07	[0.04, 0.11]	0.25	[0.13, 0.38]
e_r	0.006	[0.003, 0.01]	0.007	[0.003, 0.01]	0.007	[0.003, 0.013]	0.006	[0.003, 0.010]
e_a	0.004	[0.003, 0.005]	0.009	[0.006, 0.01]	0.008	[0.006, 0.01]	0.006	[0.005, 0.008]
e_{hf}	1.74	[1.39, 2.07]	0.14	[0.10, 0.17]	0.22	[0.17, 0.27]	0.09	[0.06, 0.12]
e_{hm}	0.07	[0.04, 0.10]	0.013	[0.002, 0.03]	0.007	[0.003, 0.012]	0.01	[0.002, 0.02]
e_{ho}	0.009	[0.002, 0.015]	0.008	[0.002, 0.01]	0.008	[0.002, 0.015]	0.009	[0.002, 0.02]

We report the estimation result figures in appendices 4.4 and 4.5. In general, the estimation results are as expected: the shapes of posterior distributions are broadly normal and the mode of posterior distribution is not excessively different from the mode calculated from the numerical optimisation of the posterior kernel. The MCMC diagnostic checks (Brooks and Gelman, 1998) also demonstrate that the results between chains are very close. The figures are provided in Appendix 4.5. However, there are some parameters that have priors very close to the posteriors. For instance, this happens to the elasticity of substitution of domestic food and non-food in the bundle of domestic goods consumption (κ) and standard error of the shock of imported oil price (e_{ho}) for all four countries' estimation. This means the data give little information about these parameters. Some parameters are also not well identified for a specific country; for example, the probability of a household having to set its wage at the previous level (θ_w) in Thailand and the elasticity of substitution among imported goods from a foreign country (γ). In such cases, we do not change the data for these countries because this would render our estimations non comparable. We want to employ the same model with the same input data to insure that the estimation results are comparable. Except for these parameters, the data are informative.

The estimation results can be classified into two groups of parameters. The first group shows the parameters with similar posterior means. These are the elasticity of substitution of domestic food and non-food in the bundle of domestic goods consumption (κ), the parameter of rigidity on non-food price (θ_{hM}), standard error of domestic interest shocks (e_r) and imported oil shocks (e_{ho}). This reflects the similarity of behaviour of the economic agents across the economies. Across countries, the parameter for rigidity in the non-food sector (θ_{hM}) is higher than the prior of 0.5 and higher than the price rigidity in the food sector (θ_{hF}) as well as wage rigidity (θ_w). This suggests prices in non-food sectors, such as in manufacturing, mining and trade, are more rigid than those for food prices or wages. The other group of parameters have different posterior means. Although they have the same priors, the differences in the data lead to quite different posterior means.

The estimation results also demonstrate that there are significant differences in how these countries conduct their monetary policy during the estimation period. All four countries have adopted ITF as their monetary policy framework. Theoretically, a country that adopts ITF should let its exchange rate float, and hence there should not be an exchange rate in its reaction function. However, we include exchange rate depreciation in this reaction function, following Lubik and Schorfheide (2007), to check whether in practice the monetary authority in these countries also responds to fluctuations in the exchange rate.

The estimation results show the four countries also consider fluctuations in the exchange rate and the output to different degrees, but their main consideration is still inflation, with the coefficient of ψ_1 unambiguously greater than unity, the minimum value required for stability according to the “Taylor Principle”. Indonesia places the highest

weight on smoothing its interest rates. No country ignores movement in output when deciding interest rates. Indonesia places the highest weight on this, followed by Korea, Philippines and Thailand respectively. All countries also consider the exchange rate when setting their interest rates. The collapse of their currencies during the Asian financial crisis perhaps still influences their monetary policy. Thailand places the highest weight on this coefficient (ψ_3). This is consistent with one of the objectives of its monetary policy, a stable exchange rate.

From this estimation we can also see which shock dominates in influencing the economy during the period 2000Q1-2010Q1. This is evident from the shocks decomposition for certain variables. We display the shock decomposition of each country's inflation as our focus is on domestic inflation. Figure 4.3 demonstrates that the shocks that most influenced Indonesia's inflation during the estimation period were foreign and domestic interest rate shocks e_{r*} . Foreign interest rate shocks influence inflation through the fluctuation of the exchange rate; we can observe the dominance of this shock during the estimation period. Meanwhile, the shocks to world oil (e_o) and food (e_{ff}) prices also influence inflation in certain periods.

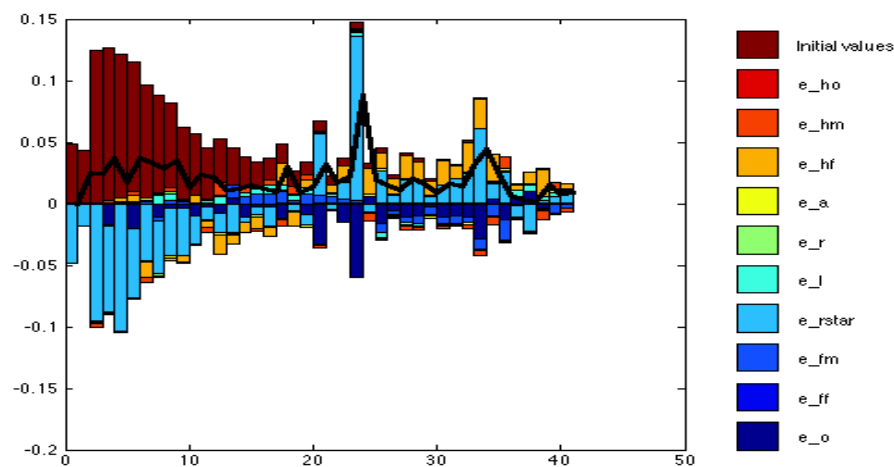


Figure 4.3. Shocks Decomposition of Indonesia's inflation

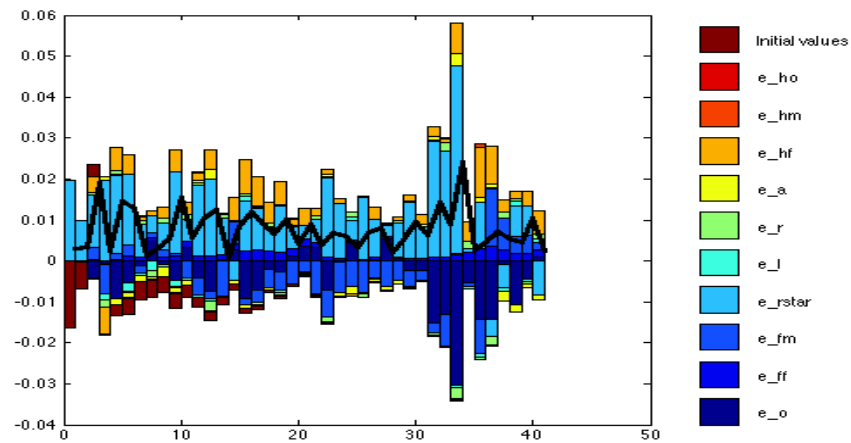


Figure 4.4. Shocks Decomposition of Korea's inflation

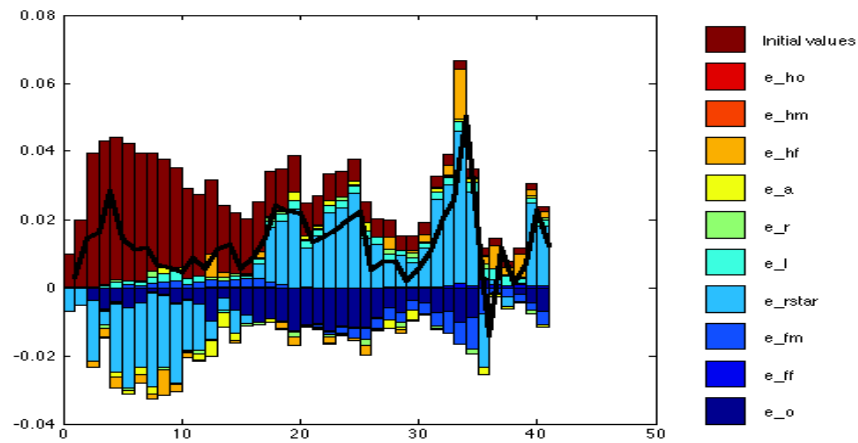


Figure 4.5. Shocks Decomposition of Philippine's inflation

For Korea, foreign interest rate shocks are also more dominant than others. The same shocks also exert a dominant influence on Philippines' Thailand's CPI. The difference is the period when these two shocks influenced the CPI.

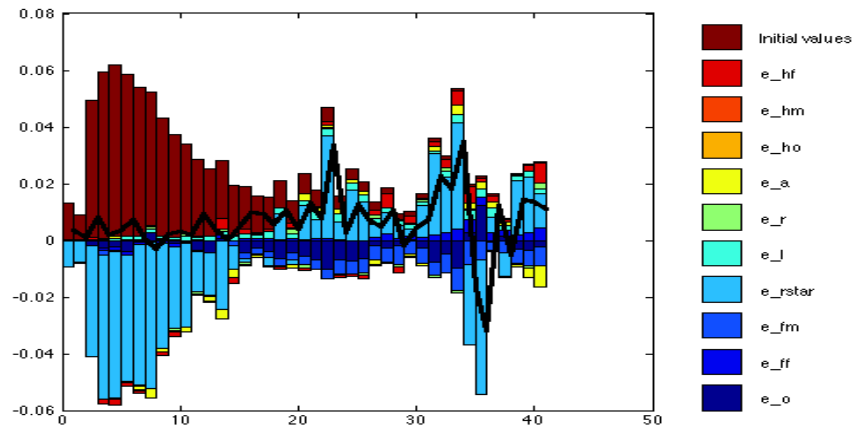


Figure 4.6. Shocks Decomposition of Thailand's inflation

4.5. Simulations

As the deep parameters of the model are known, we can solve the system of this model following the approach explained in section 4.3.1. The solution is the sequence of the state variables in terms of a function. All possible paths or sequences of the state variables match the condition from the FOC derived in this model.

We display the impulse response of monetary policy and technology shocks as in a standard simulation of a DSGE model. Given the research questions, we focus more on the impact of world oil and food price shocks on the economy, particularly the effect of the shocks on domestic inflation, namely domestic fuel and food inflation, imported price inflation, core and non-core inflation and Consumer Price Index (CPI) inflation. We shall also examine the effect on the exchange rate, the reaction of the monetary authority's policy represented by the interest rate, and the aggregate output. For GDP, interest rate and exchange rate, the impulse responses are in percentage change. The impulse responses of CPI inflation and the other types of inflation are in percentage points.

4.5.1. Monetary Policy Shock Simulation

One standard deviation of a one time shock to the policy interest rate is imposed at time $t=1$ (the first quarter). This is interpreted as an unanticipated monetary policy shock at the first time. In this simulation, an increase in the interest rate means monetary policy contraction. As a result, the nominal exchange rate appreciates and CPI inflation decreases. GDP also decreases as the expected real interest rate increases. Given the interest rate inertia in the policy rule, this shock has a permanent effect. Several variables take quarters to return to their initial values.

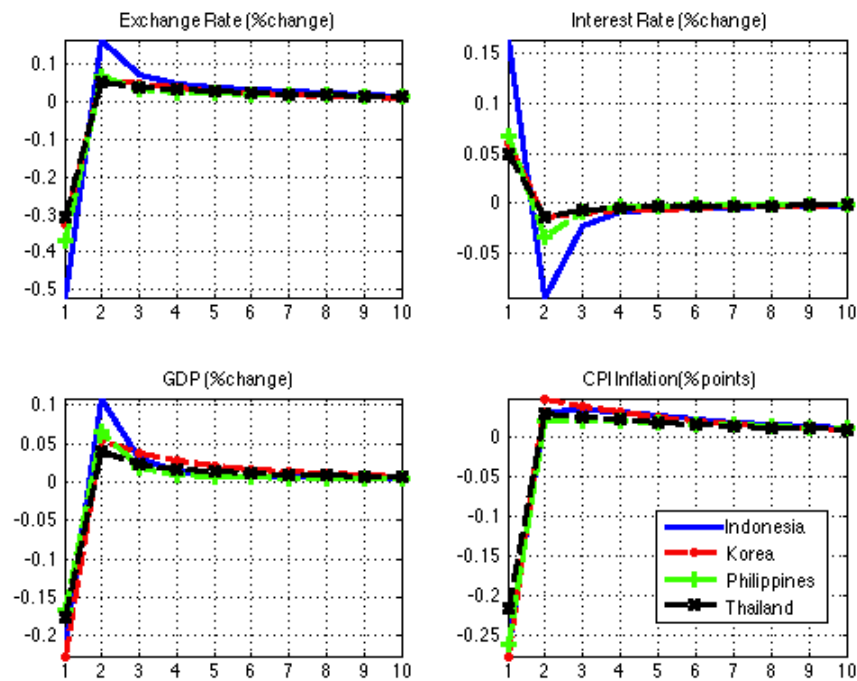


Figure 4.7. Impulse Response of Exchange Rate, Interest Rate, GDP and CPI inflation to Monetary Policy Shocks

4.5.2. Technology Shock Simulation

The positive shocks to technology increase the output of the economy, as reflected in the substantial increase in GDP. The magnitudes depend on the permanent effect of the shock. In this case, Indonesia has the lowest increase since the volatility of its

technological shock is the smallest. The increase in economic output is also reflected in the nominal exchange rate appreciation. Appreciation dampens the CPI, and this induces a lower interest rate at the beginning of the shock. After that, the appreciation lessens and gradually leads inflation back to its initial level. This stimulates the consequent interest rate increases.

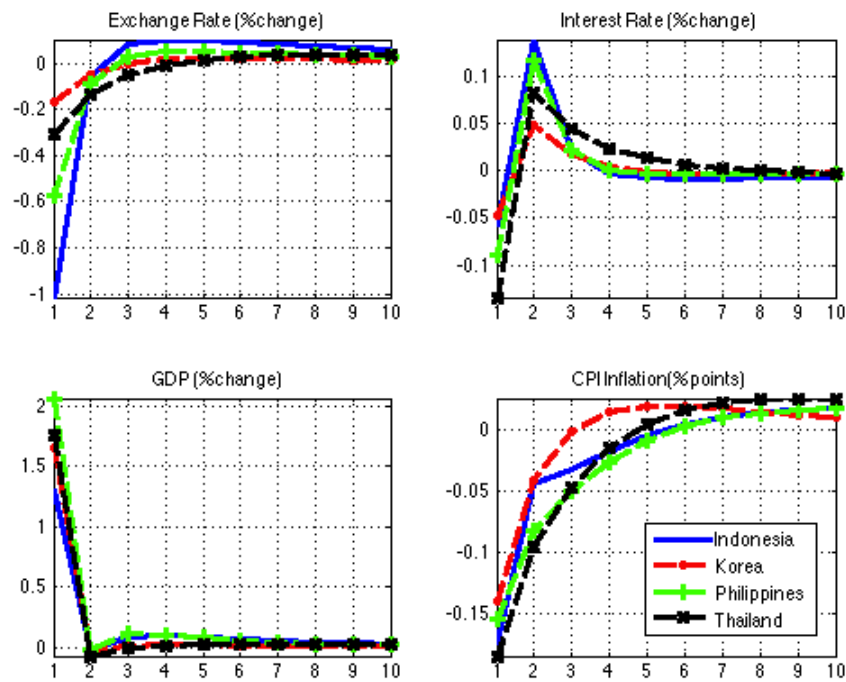


Figure 4.8. Impulse Responses of Exchange Rate, Interest Rate, GDP and CPI inflation to Technology Shocks

4.5.3. World Oil Price Shock Simulation

The world oil price shocks will be transmitted into domestic fuel inflation at the same time. The effect gradually decreases, and returns to its steady state after the fifth quarter. The magnitudes depend on the appreciation of the nominal exchange rate. In terms of import price inflation (inflation in imported goods in terms of domestic currency), all countries experience a decrease, given this appreciation.

Given the increase in domestic fuel inflation, non-core inflation increases. This inflation consists of domestic fuel and food inflation. As domestic fuel inflation increases, the cost of production in the non-food sector also increases, which results in an increase in the price of domestic non-food goods. However, the appreciation makes foreign non-food prices decrease. Overall, core inflation decreases.

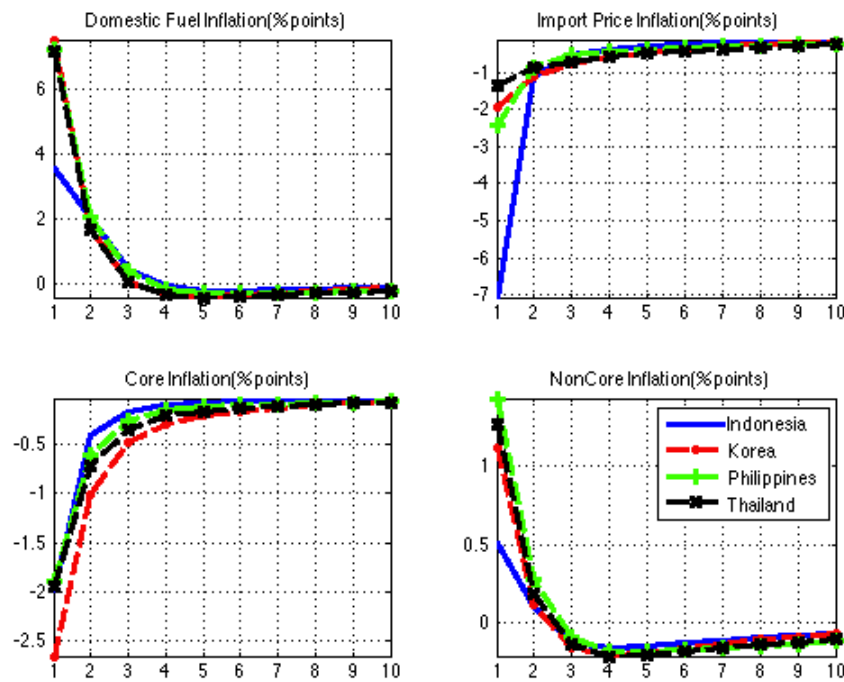


Figure 4.9. Impulse Responses of Domestic Inflation to World Oil Price Shocks

The expected increase in domestic inflation, given the world oil price shocks, reduces the real interest rate and leads to an increase in consumption as well as GDP. Given the perfect foresight assumption, economic agents know the monetary authority will increase the interest rate and this results in future appreciation of the nominal exchange rate. As the foreign interest rate is given, uncovered interest parity implies that future appreciation is reflected in the initial lower interest rate in the first place. In equilibrium, the interest rate initially decreases, in line with the appreciation of the exchange rate and

lower CPI. Subsequently, as inflation and GDP return to their initial level, the interest rate increases and gradually returns to its initial value by the fifth quarter.

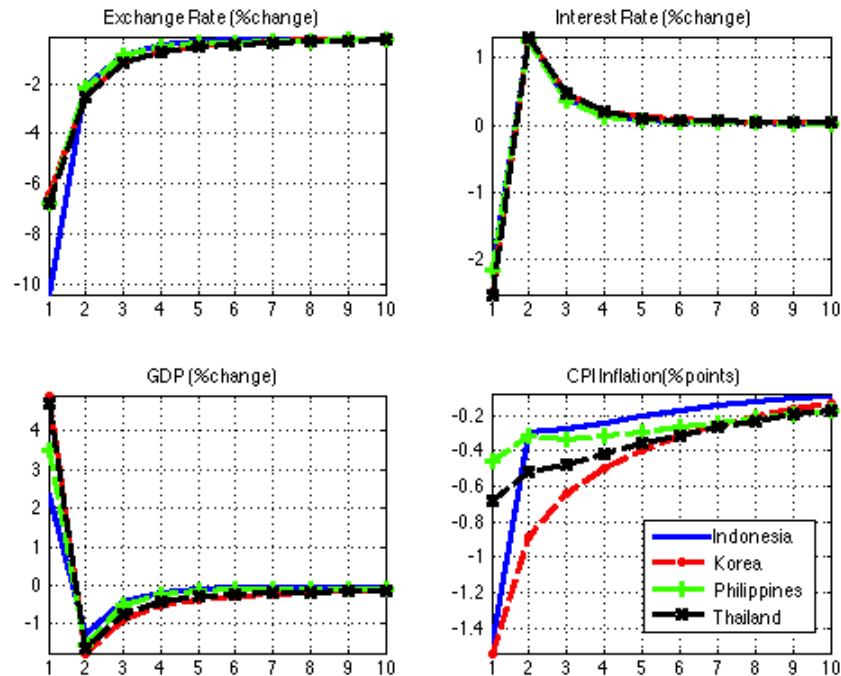


Figure 4.10. Impulse Response of Exchange Rate, Interest Rate, GDP and CPI inflation to World Oil Price Shocks

Indonesia experienced lower domestic fuel inflation given the shocks across the period because it imposed relatively high subsidies. Even though the model has no explicit subsidy feature, only in terms of imported oil shock, this simulation matched the empirical facts. This is also consistent with the previous chapter, where the first pass through of oil is lowest in Indonesia. In addition, Indonesia has a low degree of openness and low fuel preference. This means its non-core inflation is low. In contrast, a low degree of openness implies that the country relies less on foreign non-food goods, than the others. This makes households rely on the high price of domestic non-food goods because of high domestic fuel inflation. As a result, its core inflation decreases less than in the other countries.

4.5.4. World Food Price Shock Simulation

The magnitude of the world food price shock imposed in this simulation is similar to the previous one. This shock leads to foreign food inflation jumps in terms of the domestic currency. Import price inflation, as a result, increases, with greater impact in a country that has a higher preference for imported food (α_2). For Korea and Thailand, this parameter is 0.16, compared with 0.05 and 0.1 in Indonesia and Philippines respectively.

Food consumption in the economy is met by a combination of domestic production and imports. Given the shock, foreign food inflation increases. So for domestic food inflation, which is a combination of the inflation of food produced domestically and imported food in terms of domestic currency. The increase in domestic food inflation in Korea and Thailand is higher than that in Indonesia and Philippines, as will now be explained.

As foreign food prices increase, households switch from imported food to food produced domestically, which increases the demand for it. Meanwhile, the food sector, or the supply of domestic food in Korea and Thailand, is more limited than in the other two countries, as reflected in their food sector ratio. As a result, the price of food produced domestically increases. Furthermore, the foreign food preferences in these two countries are higher than in Indonesia and Philippines. The combination of these factors significantly increases domestic food inflation in Korea and Thailand and as a result, non-core inflation also increases dramatically. Meanwhile, there is a more marked decrease in core inflation in these two countries because of the greater appreciation of the nominal exchange rate.

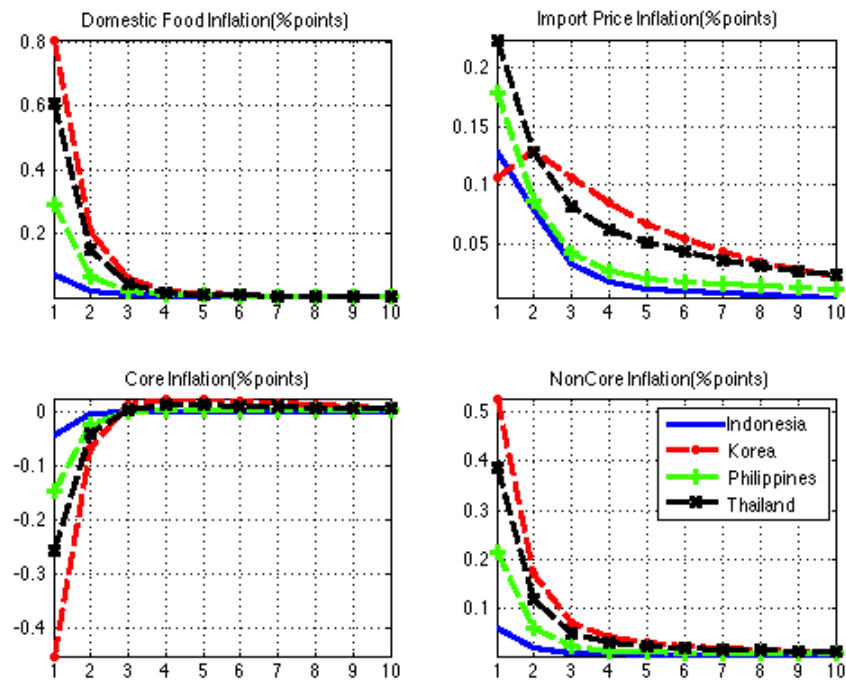


Figure 4.11. Impulse Responses of the Domestic Inflation Rate to World Food Price Shocks

As in the world oil price simulation, in this simulation the nominal exchange rate appreciates. The significant appreciation first makes the interest rate decrease. Subsequently, the interest rate increases as CPI inflation increases. On the other hand, GDP slightly decreases in the first quarter as the expected real interest rate increases; it is slightly positive afterwards. Overall, CPI inflation rises in all countries, with the smallest magnitude in the countries that have the largest food sector. This factor helps the monetary authority to dampen the effect of the shocks. In this case, Indonesia does not need to increase its interest rate sharply, but Korea, with its low food sector, should increase its interest rate more substantially. In addition, in the long run, CPI inflation in Korea is also higher.

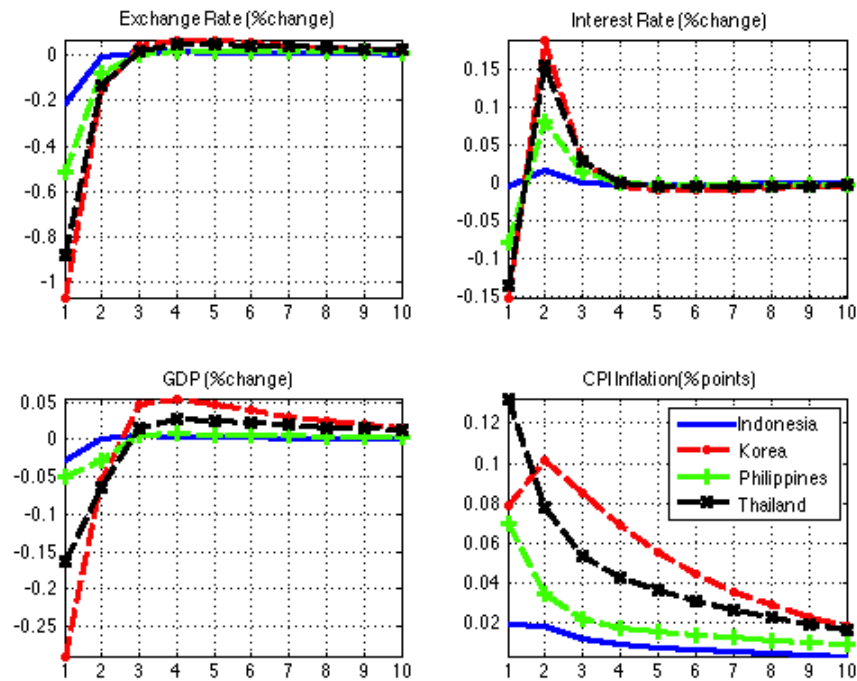


Figure 4.12. Impulse Responses of Exchange Rate, Interest Rate, GDP and CPI inflation to World Food Price Shocks

Comparing the two latter simulations, the effect of world oil price shocks on domestic inflation is greater than that of world food price shocks. This confirms the results of the first pass through in the previous chapter. Another similarity is the fact that the second pass through is not significant because the increase in world commodity prices does not increase core inflation. On the other hand, in this simulation core inflation decreases due to the effect of nominal exchange rate appreciation.

Another result of this model stresses that the capacity of a country to fulfil its domestic demand matters in the period of shocks. This factor helps the monetary authority to reduce the impact of these shocks a conclusion which is more evident in the case of world food price shocks. Indonesia, which has the largest food sector, experiences the lowest increase in CPI, even though it increases its interest rate moderately. Meanwhile,

Korea, which has the smallest food sector, experiences the highest domestic food price. It should increase its interest rate significantly in order to dampen the effects of the shocks.

Moreover, if we look at the impulse response of domestic prices over a longer period, especially CPI, this food supply factor also matters in the long term. This factor helps to impede the effect of the shock for a longer time. This happens in Indonesia, which has the highest food sector ratio. Yet Korea, which has the lowest food sector ratio, suffers a higher CPI for a longer duration. Monetary policy in the form of interest rate increases only dampens the shock briefly through the appreciation of the exchange rate. No matter which country, this finding is consistent with what was found in the previous chapter, namely that a country that has a limited supply of food will have a considerable second pass through for food. Subsequently, this will influence its CPI over the longer term. This simulation suggests that in addition to monetary policy, supply also matters.

4.6. Conclusions

This chapter explains the quantitative as well as a qualitative impact of world commodity price shocks on domestic economies, and in particular, on domestic prices in four Asian inflation targeting countries. The impacts of two types of world commodity price shock are evaluated using a DSGE model in a New Keynesian theoretical framework.

The deep parameters show that different country characteristics can coexist with broad structural similarities, noticeable in some of the deep parameters which appear close each other. However, there are also differences between the countries under investigation. A developed country, represented here by Korea, has a higher degree of openness. Developing countries, such as Indonesia, Philippines and Thailand, have higher food preferences than Korea. Engel's law applies: food expenditure in developing countries accounts for a higher budget share than in developed ones (IMF, 2008).

There are interesting differences in how the countries appear to conduct their monetary policy during the period of estimation. They all adopt inflation targeting as their monetary policy framework. From the policy rule imposed in this model, it is demonstrated that Indonesia places the highest weight on smoothing its interest rates. All countries also consider the fluctuation of output in deciding interest rates. Indonesia places the highest weight on this. For the exchange rate, all countries have a greater coefficient than that of output. Thailand places the highest weight on the coefficient of the exchange rate, which is in line with one objective of its monetary policy. In addition, the collapse of its currency during the Asian financial crisis perhaps still influences its monetary policy. In general, the weights of these two variables are relatively smaller than those of inflation. This implies that all the countries implement ITF consistently, although they do not adopt ITF strictly by focusing only on inflation and ignoring the fluctuation in other variables. The estimation results also show that shocks to the foreign interest rate have a dominant influence on the CPI inflation of each country during the period of estimation. Meanwhile, world oil and food price shocks are also influential but not as much as foreign interest rate shocks.

The simulation results show that deep parameters such as preferences play an important role in the movement of variables in response to the shocks. From the simulation of the world oil price shock, the main conclusion is that fuel preference and degree of openness play significant roles. A country that has a low fuel preference and low degree of openness experiences low domestic fuel inflation given world oil price shocks. In addition, the simulation results also capture the role of subsidy, as shown in the previous results. Indonesia, which makes relatively high subsidies, has the lowest first pass through of world oil price.

One interesting result arises in the case of world price food shock. The capacity of a country to supply its domestic demand also matters in dampening world food price shocks. In terms of domestic prices, the simulation results demonstrate that a country that has a higher food sector ratio experiences less pressure from world food price shocks. Its domestic food prices increase less than in other countries. As world food price shocks occur and generate more expensive foreign foods, households demand more domestic food. The effect of this pressure of demand is smaller, given the greater domestic food supply. In this case, its monetary authority does not need to increase its interest rate as sharply when responding to the shock. In contrast, CPI increases more in countries with lower food production as they have less capacity to meet domestic food demand. Moreover, the food supply factor matters not only in the short term or at the beginning of the shocks; in the longer term, this factor helps to dampen the effect of the shocks. Meanwhile, monetary policy only matters in the short term through the appreciation of exchange rates.

Up to this point, this model provides estimations that access the structural parameters of the economy. By introducing world price food shocks, this chapter contributes to the discussion of the impact of world commodity price shocks using a DSGE model. The estimation and simulation results of this model provide a picture of the impact of world commodity price shocks on domestic prices, at least from a theoretical perspective. The findings also support some of the empirical findings of the previous chapter. For instance, the impact of the world oil price is greater than that of the world food price. Another similarity is that the second pass through of the world commodity price shocks is limited. However, some caveats and limitations of this model should be noted.

As regards the underlying simplifications in this model, some aspects are not included. One of these is the role of subsidies, as some developing countries still allocate subsidies for fuel and food consumption. It is necessary to model the subsidy explicitly to make the model closer to reality. In addition, the assumption of LOOP might be unrealistic given the low degree of ERPT for some countries revealed in the previous chapter. As regards the estimation, more data may be needed in terms of the number of observations, as well as the number of variables. This may help to make the data more informative about some parameters and make the estimation more robust. For calibration, some parameters need to be calibrated in a more precise way to closely mimic the condition of each country; for instance, the parameter of domestic food preference. We need to calibrate this parameter more precisely because it is also equal to the ratio of food sectors to output. This ratio significantly influences the transmission mechanism of the model. Besides representing household preference, it should capture the capacity of a country to fulfil the domestic demand for food. Some assumptions of this model could also be too strong. For instance, there is no oil in the production function of firms in the food sectors. In reality, these firms also need oil as a production factor or for fertilizer. This model does not capture this.

The New Keynesian DSGE model used in this chapter relies, like most studies, on Calvo pricing. Is Calvo pricing an empirically acceptable hypothesis? Chapter 5 will cast light on this. This model also adopts a common assumption of a frictionless financial market and uses a single interest rate. The relationship between a central bank's policy rate and the commercial deposit rate may be less than perfect and financial frictions may distort agents' behaviour. Enhancing this model with a financial friction feature would be interesting and challenging; see, for example, Curdia and Woodford (2009) and Quadrini

(2011). Furthermore, there is a possibility of multiple equilibria of the inflation path in this kind of model, as noted in Cochrane (2011). These are unsettled issues that question the confidence we have in New Keynesian DSGE model, although this model is still a valuable approach that has not been superseded by any alternative approach.

These limitations could become the agenda for further research. Given this, this model should not be treated as a full representation of the economy. However, it is sufficient to act as guidance in evaluating certain aspects of the economy, such as in the case given above.

Appendix 4.1. Notation

Parameter	Description
α	Degree of openness or foreign bias preferences
α_1	Foreign oil (fuel) preferences of household
α_2	Foreign food preferences of household
α_3	Domestic food preferences of household
ϕ	Labour share in non-food production function
ϕ_L	Labour share in food producer production function
φ	The inverse elasticity of labour supply
σ	The inverse elasticity of intertemporal substitution or constant coefficient relative risk of aversion (CRRA)
η	Elasticity of substitution between domestic and foreign good in household bundle of consumption
κ	Elasticity of substitution between food and non food in household bundle of consumption
γ	Elasticity of substitution among imported goods from foreign countries i
θ_{hM}	Probability of manufacturer that set their price based on the previous price
θ_w	Probability of household that set their wage based on the previous wage
θ_{hF}	Probability of food producer that set their price based on to the previous price
ρ	Coefficient of interest rate inertia in policy rule
ψ_1	Coefficient of inflation in policy rule
ψ_2	Coefficient of output in policy rule
ψ_3	Coefficient of exchange rate in policy rule
ρ_a	Coefficient of productivity or technology AR(1) model
ρ_o	Coefficient of world oil price AR(1) model
ρ_{fM}	Coefficient of world non food price AR(1) model
ρ_{fF}	Coefficient of world food price AR(1) model
ρ_{r^*}	Coefficient of foreign interest rate AR(1) model
ρ_l	Coefficient of land price AR(1) model
$\varepsilon_w, \varepsilon_{hM}, \varepsilon_{hF}$	Elasticity of substitution among j type of skill/good in labour, food and non-food

Variables	Description
C	Household consumption
C_h	Consumption of domestic goods
C_{hM}	Consumption of domestic non-food goods
C_{hF}	Consumption of domestic food
C_o	Consumption of imported oil
C_{fF}	Consumption of imported food
C_{fM}	Consumption of imported non-food goods
C_f	Consumption of foreign goods
N	Labour time
P	Consumer price index
P_h	Price index of domestic goods
P_{hM}	Price index of domestic non-food goods
P_{hF}	Price index of domestic food
P_o	Price index of imported oil
P_{fF}	Price index of imported food
P_{fM}	Price index of imported non-food goods
P_f	Price index of foreign goods
π	Inflation rate. Inflation rate of each type of good are with subscript as in the price index
D	Financial asset belong to household
W	Wage received by household
Q	Discount factor of financial asset
R	The interest rate
Π	Profit
O	Oil as an input in domestic non-food firm production function
L	Land as an input in domestic food firm production function
A	Total factor productivity in firm production function
MC/MRS	Marginal cost /Marginal rate of substitution between consumption and labour
Y	Output or firm's production
S	Effective terms of trade
ϵ	Bilateral nominal exchange rate
e	Nominal effective exchange rate
q	Real effective exchange rate

Appendix 4.2. Model Derivation

Households

A household maximizes his utility subject to his budget constraint:

$$\text{Max} \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right]$$

$$\text{S.t} \quad P_t C_t + E\{Q_{t,t+1} D_{t+1}\} \leq D_t + W_t N_t$$

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} + \lambda_t [D_t + W_t N_t + T_t - P_t C_t - E\{Q_{t,t+1} D_{t+1}\}] \right]$$

$$\frac{\partial \mathcal{L}}{\partial C_t} = \beta^t [C_t^{-\sigma} - \lambda_t P_t] = 0$$

$$C_t^{-\sigma} - \lambda_t P_t = 0 \quad (4A.1)$$

$$\frac{\partial \mathcal{L}}{\partial D_{t+1}} = -\beta^t \lambda_t Q_{t,t+1} + \beta^{t+1} \lambda_{t+1} = 0$$

$$\lambda_{t+1} = \frac{\beta^t \lambda_t Q_{t,t+1}}{\beta^{t+1}} = \frac{\lambda_t Q_{t,t+1}}{\beta} \quad (4A.2)$$

From (4A.1), we get

$$\lambda_t = \frac{C_t^{-\sigma}}{P_t} \quad \text{thus} \quad \lambda_{t+1} = \frac{C_{t+1}^{-\sigma}}{P_{t+1}}$$

Combine above equation with (4A.1) and (4A.2), we get

$$C_t^{-\sigma} = C_{t+1}^{-\sigma} \frac{P_t}{P_{t+1}} \frac{\beta}{Q_{t,t+1}}$$

$$\beta \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) = Q_{t,t+1}$$

Take the conditional expectation, we obtain the Euler equation:

$$\beta R_t E_t \left\{ \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) \right\} = 1 \quad (4A.3)$$

$$\text{where } R_t = \frac{1}{E_t\{Q_{t,t+1}\}}$$

Each household consume the bundle of consumption goods that consists of domestic and foreign good consumption.

$$C_t \equiv \left[(1-\alpha)^{\frac{1}{\eta}} (C_{h,t})^{\frac{\eta-1}{\eta}} + (\alpha)^{\frac{1}{\eta}} (C_{f,t})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \quad (4A.4)$$

We assume there are firms that combine foreign and domestically produced goods into composite of good that is consumed by households. These firms buy domestic and foreign goods, combine them and sell them to the household to get their profit. It can be

said that these firms help household to find the best combination of foreign and domestic goods. They maximize their profit in a perfectly competitive market.

$$\text{Max } \Pi = P_t C_t - P_{h,t} C_{h,t} - P_{f,t} C_{f,t}$$

$$\text{Subject to } C_t \equiv \left[(1 - \alpha)^{\frac{1}{\eta}} (C_{h,t})^{\frac{\eta-1}{\eta}} + (\alpha)^{\frac{1}{\eta}} (C_{f,t})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

Plug the combination of goods into the profit function, we get

$$\Pi = P_t \left((1 - \alpha)^{\frac{1}{\eta}} C_{h,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{f,t}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} - P_{h,t} C_{h,t} - P_{f,t} C_{f,t}$$

Using definition of C_t and simplify it, we get

$$\begin{aligned} \frac{\partial \Pi}{\partial C_{h,t}} &= P_t \frac{\eta}{\eta-1} \left((1 - \alpha)^{\frac{1}{\eta}} C_{h,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{f,t}^{\frac{\eta-1}{\eta}} \right)^{\frac{1}{\eta-1}} \frac{\eta-1}{\eta} (1 - \alpha)^{\frac{1}{\eta}} C_{h,t}^{-\frac{1}{\eta}} - P_{h,t} = 0 \\ C_{h,t} &= (1 - \alpha) \left(\frac{P_{h,t}}{P_t} \right)^{-\eta} C_t \end{aligned} \quad (4A.5)$$

Analogously, we derive the profit function with respect to $C_{f,t}$, yielding the demand for foreign goods:

$$C_{f,t} = \alpha \left(\frac{P_{f,t}}{P_t} \right)^{-\eta} C_t \quad (4A.6)$$

If we plug (4A.5) and (4A.6) into (4A.4) we get

$$\begin{aligned} C_t &= \left[(1 - \alpha)^{\frac{1}{\eta}} \left((1 - \alpha) \left(\frac{P_{h,t}}{P_t} \right)^{-\eta} C_t \right)^{\frac{\eta-1}{\eta}} + (\alpha)^{\frac{1}{\eta}} \left(\alpha \left(\frac{P_{f,t}}{P_t} \right)^{-\eta} C_t \right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \\ C_t^{\frac{\eta-1}{\eta}} &= (1 - \alpha)^{\frac{1}{\eta}} \left((1 - \alpha) \left(\frac{P_{h,t}}{P_t} \right)^{-\eta} C_t \right)^{\frac{\eta-1}{\eta}} + (\alpha)^{\frac{1}{\eta}} \left(\alpha \left(\frac{P_{f,t}}{P_t} \right)^{-\eta} C_t \right)^{\frac{\eta-1}{\eta}} \\ P_t &= \left[(1 - \alpha) P_{h,t}^{1-\eta} + \alpha P_{f,t}^{1-\eta} \right]^{\frac{1}{1-\eta}} \end{aligned} \quad (4A.7)$$

The above equation is the consumer price index.

The firms that combine foreign goods with domestic goods buy the foreign good from other firms, namely importer. These importers help the above firms to find the best combination of three types of foreign goods namely oil, food and other foreign good into one bundle foreign goods.

$$C_f \equiv \left[(1 - \alpha_1 - \alpha_2)^{\frac{1}{v}} (C_{fM,t})^{\frac{v-1}{v}} + (\alpha_1)^{\frac{1}{v}} (C_{O,t})^{\frac{v-1}{v}} + (\alpha_2)^{\frac{1}{v}} (C_{fF,t})^{\frac{v-1}{v}} \right]^{\frac{v}{v-1}} \quad (4A.8)$$

where $C_{fM,t} \equiv \left(\int_0^1 C_{fM,t}^i \frac{\gamma-1}{\gamma} di \right)^{\frac{\gamma}{\gamma-1}}$ and $C_{fF,t} \equiv \left(\int_0^1 C_{fF,t}^i \frac{\gamma-1}{\gamma} di \right)^{\frac{\gamma}{\gamma-1}}$ is the consumption of imported goods other than oil.

These importers also maximize their profit subject to the bundle of foreign goods in a perfectly competitive environment.

$$\text{Max } \Pi = P_{f,t} C_{f,t} - P_{fM,t} C_{fM,t} - P_{O,t} C_{O,t} - P_{fF,t} C_{fF,t}$$

$$\text{Subject to } C_f \equiv \left[(1 - \alpha_1 - \alpha_2)^{\frac{1}{v}} (C_{fM,t})^{\frac{v-1}{v}} + (\alpha_1)^{\frac{1}{v}} (C_{O,t})^{\frac{v-1}{v}} + (\alpha_2)^{\frac{1}{v}} (C_{fF,t})^{\frac{v-1}{v}} \right]^{\frac{v}{v-1}}$$

The derivations of the profit function w.r.t. $C_{fM,t}$, $C_{O,t}$, $C_{fF,t}$ yield the demand for three types of foreign goods respectively:

$$C_{fM,t} = (1 - \alpha_1 - \alpha_2) \left(\frac{P_{fM,t}}{P_{f,t}} \right)^{-v} C_{f,t} \quad (4A.9)$$

$$C_{O,t} = \alpha_1 \left(\frac{P_{O,t}}{P_{f,t}} \right)^{-v} C_{f,t} \quad (4A.10)$$

$$C_{fF,t} = \alpha_2 \left(\frac{P_{fF,t}}{P_{f,t}} \right)^{-v} C_{f,t} \quad (4A.11)$$

Analogously by plugging the above demand function into the composite of foreign good consumption will yield the composite index price of foreign goods as follows:

$$P_{f,t} = \left[(1 - \alpha_1 - \alpha_2) P_{fM,t}^{1-v} + \alpha_1 P_{O,t}^{1-v} + \alpha_2 P_{fF,t}^{1-v} \right]^{\frac{1}{1-v}} \quad (4A.12)$$

Analogously for the bundlers of domestic goods, these bundlers help to find the best combination of two types of domestic goods namely non-food and food into one bundle of domestic goods. These bundlers also maximize their profit subject to the bundle of domestic goods in a perfectly competitive environment:

$$\text{Max } \Pi = P_{h,t} C_{h,t} - P_{hM,t} C_{hM,t} - P_{hF,t} C_{hF,t}$$

$$\text{Subject to } C_{h,t} \equiv \left[(1 - \alpha_3)^{\frac{1}{\kappa}} (C_{hM,t})^{\frac{\kappa-1}{\kappa}} + (\alpha_3)^{\frac{1}{\kappa}} (C_{hF,t})^{\frac{\kappa-1}{\kappa}} \right]^{\frac{\kappa}{\kappa-1}}$$

This will yield the composite index price of domestic goods as follows:

$$P_{h,t} = \left[(1 - \alpha_3) P_{hM,t}^{1-\kappa} + \alpha_3 P_{hF,t}^{1-\kappa} \right]^{\frac{1}{1-\kappa}} \quad (4A.13)$$

Meanwhile, demand for product (j) produced by domestic non-food firms is derived from cost minimization of household expenditure on consumption of domestic non-food goods (C_{hM}).

$$\text{Min } \int_0^1 P_{hM,t}(j) C_{hM,t}(j) dj$$

subject to $C_{hM,t} = \left(\int_0^1 C_{hM,t}(j)^{\frac{\varepsilon_{hM}-1}{\varepsilon_{hM}}} dj \right)^{\frac{\varepsilon_{hM}}{\varepsilon_{hM}-1}}$

$$\mathcal{L} = \int_0^1 P_{hM,t}(j) C_{hM,t}(j) dj + \lambda_t \left[C_{hM,t} - \left(\int_0^1 C_{hM,t}(j)^{\frac{\varepsilon_{hM}-1}{\varepsilon_{hM}}} dj \right)^{\frac{\varepsilon_{hM}}{\varepsilon_{hM}-1}} \right]$$

$$\frac{\partial \mathcal{L}}{\partial C_{hM,t}(j)} = P_{hM,t}(j) - \lambda_t \frac{\varepsilon_{hM}}{\varepsilon_{hM}-1} \left(\int_0^1 C_{hM,t}(j)^{\frac{\varepsilon_{hM}-1}{\varepsilon_{hM}}} dj \right)^{\frac{1}{\varepsilon_{hM}-1}} \frac{\varepsilon_{hM}-1}{\varepsilon_{hM}} C_{hM,t}(j)^{\frac{-1}{\varepsilon_{hM}}} = 0$$

$$P_{hM,t}(j) = \lambda_t C_{hM,t}^{\frac{1}{\varepsilon_{hM}}} C_{hM,t}(j)^{\frac{-1}{\varepsilon_{hM}}}$$

Multiplied by $C_{hM,t}(j)$ and integrate it will yield

$$\int_0^1 P_{hM,t}(j) C_{hM,t}(j) dj = \lambda_t C_{hM,t}^{\frac{1}{\varepsilon_{hM}}} \int_0^1 C_{hM,t}(j)^{\frac{-1+\varepsilon_{hM}}{\varepsilon_{hM}}} dj$$

$$P_{hM,t} = \lambda_t$$

The above equation implies the Lagrange multiplier equal to the domestic non-food good price index. Given that, we replace the Lagrange multiplier to get the demand for domestic non-food good (j) by domestic household.

$$P_{hM,t}(j) = P_{hM,t} C_{hM,t}^{\frac{1}{\varepsilon_{hM}}} C_{hM,t}(j)^{\frac{-1}{\varepsilon_{hM}}}$$

$$C_{hM,t}(j) = \left(\frac{P_{hM,t}(j)}{P_{hM,t}} \right)^{-\varepsilon_{hM}} C_{hM,t} \quad (4A.14)$$

Analogously, we can find the demand for food j as follows:

$$C_{hF,t}(j) = \left(\frac{P_{hF,t}(j)}{P_{hF,t}} \right)^{-\varepsilon_{hW}} C_{hF,t} \quad (4A.15)$$

By similar optimization we find the optimal allocation of imported non-food good j and food j from country i is respectively as follow:

$$C_{fM,t}(j) = \left(\frac{P_{fM,t}(j)}{P_{fM,t}} \right)^{-\varepsilon_{hM}} C_{fM,t} \quad (4A.16)$$

$$C_{fF,t}(j) = \left(\frac{P_{fF,t}(j)}{P_{fF,t}} \right)^{-\varepsilon_{hW}} C_{fF,t} \quad (4A.17)$$

And the optimal budget allocation on imported goods by country of origin can be defined as follows:

$$C_{i,t} = \left(\frac{P_{i,t}}{P_{f,t}} \right)^{-\gamma} C_{f,t} \quad (4A.18)$$

Where $P_{f,t} = \left(\int_0^1 P_{i,t}^{1-\gamma} di \right)^{\frac{1}{1-\gamma}}$ or the price index of imported goods from all countries expressed in domestic currency.

The Demand for Labour

The households supply labour to the firms. They work based on the skill they have. Those skills are imperfectly substitutes so the households have some monopolistic power. They decide how much the labour time they supply. They consider how much the income they get and how much the leisure time they sacrifice as a consequence. Their sacrifice is measured in terms of the marginal rate of substitution. In their optimization, the households consider the demand for their labour comes from the firms.

We have two sectors of production: non-food and food sector or manufacturing and agriculture sector. We assume the demand for skill j in the two sectors is identical for simplification and based on these reasons:

- Non-food sectors, for instance manufacturing sectors, also need workers, not only managers.
- Food sector or food producer to some extent also includes manufacturing processes. Even if the sector consists only of fields or plantations, they also need agriculture engineers.

Given this assumption, the wage that is set by the households will be the same across sectors because it is related to the same skill they supply. Hence, the firms in each sector determine the demand for the labour of each j skill. The firms will minimize the labour cost given the wage, subject to the total labour they need as follows:

$$\text{Min } \int_0^1 W_t(j) N_t(j) dj$$

subject to

$$N_t = \left(\int_0^1 N_t(j)^{\frac{\varepsilon_w-1}{\varepsilon_w}} dj \right)^{\frac{\varepsilon_w}{\varepsilon_w-1}}$$

$$\mathcal{L} = \int_0^1 W_t(j) N_t(j) dj + \lambda_t \left[N_t - \left(\int_0^1 N_t(j)^{\frac{\varepsilon_w-1}{\varepsilon_w}} dj \right)^{\frac{\varepsilon_w}{\varepsilon_w-1}} \right]$$

$$\frac{\partial \mathcal{L}}{\partial N_t(j)} = W_t(j) - \lambda_t \frac{\varepsilon_w}{\varepsilon_w-1} \left(\int_0^1 N_{H,t}(j)^{\frac{\varepsilon_w-1}{\varepsilon_w}} dj \right)^{\frac{1}{\varepsilon_w-1}} \frac{\varepsilon_w-1}{\varepsilon_w} N_t(j)^{\frac{-1}{\varepsilon_w}} = 0$$

$$W_t(j) = \lambda_t \left(N_t^{\frac{\varepsilon_w-1}{\varepsilon_w}} \right)^{\frac{1}{\varepsilon_w-1}} N_t(j)^{\frac{-1}{\varepsilon_w}}$$

$W_t(j) = \lambda_t N_t^{\frac{1}{\varepsilon_w}} N_t(j)^{\frac{-1}{\varepsilon_w}}$, multiply this by $N_t(j)$ and integrate it over all skills

$$\int_0^1 N_t(j) W_t(j) dj = \lambda_t N_t^{\frac{1}{\varepsilon_w}} \int_0^1 N_t(j)^{\frac{\varepsilon_w-1}{\varepsilon_w}} dj$$

$$N_t W_t = \lambda_t N_t \quad \text{or} \quad W_t = \lambda_t$$

Given this, we have

$$W_t(j) = W_t \frac{N_t^{\frac{1}{\varepsilon_w}}}{N_t(j)^{\frac{1}{\varepsilon_w}}} \quad \text{or} \quad N_t(j)^{\frac{1}{\varepsilon_w}} = \frac{W_t}{W_t(j)} N_t^{\frac{1}{\varepsilon_w}}$$

Hence, the demand for labour of skill j in each sector:

$$N_{hM,t}(j) = \left(\frac{W_t}{W_t(j)} \right)^{\varepsilon_w} N_{hM,t} \quad (4A.19)$$

$$N_{hF,t}(j) = \left(\frac{W_t}{W_t(j)} \right)^{\varepsilon_w} N_{hF,t} \quad (4A.20)$$

$$\text{In total,} \quad N_{hM,t}(j) + N_{hF,t}(j) = \left(\frac{W_t}{W_t(j)} \right)^{\varepsilon_w} (N_{hM,t} + N_{hF,t})$$

$$N_t(j) = \left(\frac{W_t}{W_t(j)} \right)^{\varepsilon_w} N_t \quad (4A.21)$$

Nominal Wage

We follow Erceg et al. (2000) to find the wage inflation equation given above assumptions. As we know, households have utility function: $U(C_t, N_t)$, and budget constraint given the effective wage: $P_t C_t + E_t\{Q_{t,t+1} D_{t+1}\} \leq D_t + \bar{W}_t N_t$

$$\text{Or in terms of consumption: } C_t = \frac{1}{P_t} (D_t + \bar{W}_t N_t - E_t\{Q_{t,t+1} D_{t+1}\})$$

$$\text{Demand for labour: } N_{t+k}^d = \left(\frac{\bar{W}_t}{W_{t+k}} \right)^{-\varepsilon_w} N_{t+k}$$

The household will maximize utility subject to the budget constraint and the demand for labour. Substituting the later two into utility will yield the present value of their income.

$$\begin{aligned} \text{Max} \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \left\{ U \left[\frac{1}{P_{t+k}} \left(D_{t+k} + \bar{W}_t \left(\frac{\bar{W}_t}{W_{t+k}} \right)^{-\varepsilon_w} N_{t+k} \right. \right. \right. \\ \left. \left. \left. - E_t\{Q_{t,t+1} D_{t+1}\} \right), \left(\frac{\bar{W}_t}{W_{t+k}} \right)^{-\varepsilon_w} N_{t+k} \right] \right\} \end{aligned}$$

Differentiation with respect to \bar{W}_t and using chain rule, yields the FOC:

$$\begin{aligned} \frac{\partial V}{\partial \bar{W}_t} &= \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \left\{ U_c \frac{1}{P_{t+k}} (1 - \varepsilon_w) \left(\frac{\bar{W}_t}{W_{t+k}} \right)^{-\varepsilon_w} N_{t+k} - U_N \varepsilon_w \frac{1}{\bar{W}_t} \left(\frac{\bar{W}_t}{W_{t+k}} \right)^{-\varepsilon_w} N_{t+k} \right\} \\ &= 0 \\ \frac{\partial V}{\partial \bar{W}_t} &= \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \left\{ U_c \frac{1}{P_{t+k}} (1 - \varepsilon_w) N_{t+k}^d - U_N \varepsilon_w \frac{1}{\bar{W}_t} N_{t+k}^d \right\} = 0 \end{aligned}$$

Multiply both sides with $\frac{\bar{W}}{(1-\varepsilon_w)}$

$$\frac{\partial V}{\partial \bar{W}_t} = \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \left\{ U_c \frac{\bar{W}_t}{P_{t+k}} N_{t+k}^d + U_N \frac{\varepsilon_w}{\varepsilon_w - 1} N_{t+k}^d \right\} = 0$$

We have marginal rate of substitution $MRS = -\frac{U_N}{U_c}$

$$\frac{\partial V}{\partial \bar{W}_t} = \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \left\{ U_c N_{t+k}^d \left[\frac{\bar{W}_t}{P_{t+k}} - MRS_{t+k} \frac{\varepsilon_w}{\varepsilon_w - 1} \right] \right\} = 0$$

Given the utility function we get $U_c = C^{-\sigma}$

$$\frac{\partial V}{\partial \bar{W}_t} = \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \left\{ C_{t+k}^{-\sigma} P_{t+k}^{-1} N_{t+k}^d \left[\bar{W}_t - \frac{\varepsilon_w}{\varepsilon_w - 1} MRS_{t+k} P_{t+k} \right] \right\} = 0$$

Let $\Gamma_{t+k} = C_{t+k}^{-\sigma} P_{t+k}^{-1} N_{t+k}^d$ and multiply by $\frac{W_{t-1}}{W_{t-1}}$

$$\sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \left\{ \bar{W}_t \Gamma_{t+k} \frac{W_{t-1}}{W_{t-1}} \right\} = \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \left\{ \Gamma_{t+k} \frac{\varepsilon_w}{\varepsilon_w - 1} MRS_{t+k} P_{t+k} \frac{W_{t-1}}{W_{t-1}} \frac{W_{t+k}}{W_{t+k}} \right\}$$

Now let $\Pi_{t-1,t+k} = \frac{W_{t+k}}{W_{t-1}}$, we get

$$\sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \{ \bar{W}_t \Gamma_{t+k} \} = \frac{\varepsilon_w}{\varepsilon_w - 1} W_{t-1} \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \left\{ \Gamma_{t+k} MRS_{t+k} \frac{P_{t+k}}{W_{t+k}} \Pi_{t-1,t+k} \right\} \quad (4A.22)$$

Firms

There are two types of firms that refer to the two sectors in the economy: non-food and food firms. In this section we discuss the behaviour of domestic firms that produce domestic non-food good for household consumption $C_{hM,t}$. Each firm is identical and produces product j . The firm employs labour provided by the household and use oil for its production. Every period domestic firm minimizes its cost of production.

$$\text{Min } W_t N_t + P_{O,t} O_t$$

subject to Cobb-Douglas production function that includes oil as the input.

$$Y_t = A_t N_t^\phi O_t^{1-\phi}$$

$$\mathcal{L} = W_t N_t + P_{O,t} O_t + \lambda_t (A_t N_t^\phi O_t^{1-\phi})$$

Differentiating w.r.t. labour and oil yield

$$\frac{\partial \mathcal{L}}{\partial N_t} = W_t + \lambda_t A_t \phi N_t^{\phi-1} O_t^{1-\phi} = 0$$

$$\frac{\partial \mathcal{L}}{\partial O_t} = P_{O,t} + \lambda_t A_t (1 - \phi) N_t^\phi O_t^{-\phi} = 0$$

Equate both equation, we get the oil and labour ratio,

$$\frac{O_t}{N_t} = \frac{1-\phi}{\phi} \frac{W_t}{P_{O,t}}$$

Substitute to the production function to get the demand for labour:

$$Y_t = A_t N_t^\phi \left(N_t \frac{W_t}{P_{O,t}} \frac{1-\phi}{\phi} \right)^{1-\phi}$$

$$N_t = \frac{1}{A_t} \left(\frac{P_{O,t}}{W_t} \frac{\phi}{1-\phi} \right)^{1-\phi} Y_t \quad (4A.23)$$

Using the same way to get the demand for oil:

$$O_t = \frac{1}{A_t} \left(\frac{W_t}{P_{O,t}} \frac{1-\phi}{\phi} \right)^\phi Y_t \quad (4A.24)$$

The demand for labour (4A.22) and oil (4A.23) are needed to calculate the marginal cost of production. This marginal cost is needed to calculate the profit of the firms. Substitute the demand function into the cost function,

$$Cost = W_t \frac{1}{A_t} \left(\frac{P_{O,t}}{W_t} \frac{\phi}{1-\phi} \right)^{1-\phi} Y_t + P_{O,t} \frac{1}{A_t} \left(\frac{W_t}{P_{O,t}} \frac{1-\phi}{\phi} \right)^\phi Y_t$$

$$Cost = \frac{1}{A_t} P_{O,t}^{1-\phi} W_t^\phi \left(\frac{1}{1-\phi} \right) \left(\frac{1-\phi}{\phi} \right)^\phi Y_t$$

From this equation we get the nominal marginal cost (MC_t^n):

$$\frac{\partial Cost}{\partial Y_t} = MC_t^n = \frac{1}{A_t} P_{O,t}^{1-\phi} W_t^\phi \left(\frac{1}{1-\phi} \right) \left(\frac{1-\phi}{\phi} \right)^\phi$$

The real marginal cost in terms of domestic non-food price is

$$MC_t = \frac{1}{A_t} \frac{1}{P_{hM,t}} P_{O,t}^{1-\phi} W_t^\phi \left(\frac{1}{1-\phi} \right) \left(\frac{1-\phi}{\phi} \right)^\phi \quad (4A.25)$$

We can rewrite equation (4A.25):

$$MC_t = \frac{1}{A_t} \frac{P_t}{P_{hM,t}} \left(\frac{P_{O,t}}{P_t} \right)^{1-\phi} \left(\frac{W_t}{P_t} \right)^\phi \left(\frac{1}{1-\phi} \right) \left(\frac{1-\phi}{\phi} \right)^\phi \quad (4A.26)$$

The equation of the demand for production factor (oil, labour, and land) and the real marginal cost applies to both food and non-food firms. The difference is the price of oil in non-food firms is replaced by the price of land in food firms.

Price of Domestic Good

Domestic firms are monopolistic competitors, setting prices by maximizing profit subject to the demands for their product. However, prices are staggered. We follow Calvo (1983) model: there is a fraction of θ of the firms that does not change their price and

another fraction $(1 - \theta)$ reset their price based on optimization. The Calvo price setting suggests, $P_{hM,t+k}(j) = \bar{P}_{hM,t}(j)$, that the price will be set at the previous effective price with probability $\theta^k (k = 0, 1, 2, \dots)$. As a result, the remainder $(1 - \theta)$ of the firms maximize the present value of their profit as follows.

$$\text{Max } \sum_{k=0}^{\infty} \theta^k E_t \{ Q_{t,t+k} [Y_{t+k}(j) (\bar{P}_{hM,t} - MC_{t+k}^n)] \}$$

subject to the sequence of demand constraint:

$$Y_{t+k}(j) \leq \left(\frac{\bar{P}_{hM,t}(j)}{P_{hM,t+k}} \right)^{-\varepsilon_{hM}} \left(C_{hM,t+k}(j) + \int_0^1 C_{hM,t+k}^i(j) di \right) \equiv Y_{t+k}^d(\bar{P}_{hM,t})$$

This constraint consists of demand for its product from domestic and foreign households. The sequence of aggregate demand $Y_{t+k}^d(j)$ is also based on the effective price $\bar{P}_{hM,t}(j)$ at time t. Since all firms will have the same optimal price $(\bar{P}_{hM,t})$, then we eliminate the subscript j so that the maximization problem becomes as follows.

$$\text{Max } \sum_{k=0}^{\infty} \theta^k E_t \{ Q_{t,t+k} [Y_{t+k}^d(\bar{P}_{hM,t} - MC_{t+k}^n)] \}$$

$$\text{subject to } Y_{t+k}^d = \left(\frac{\bar{P}_{hM,t}}{P_{hM,t+k}} \right)^{-\varepsilon_{hM}} \left(C_{hM,t} + \int_0^1 C_{hM,t}^i di \right) \text{ or}$$

$$Y_{t+k}^d = \left(\frac{\bar{P}_{hM,t}}{P_{hM,t+k}} \right)^{-\varepsilon_{hM}} Y_{t+k}$$

$$V = \sum_{k=0}^{\infty} \theta^k E_t Q_{t,t+k} \left[\bar{P}_{hM,t} \left(\frac{\bar{P}_{hM,t}}{P_{hM,t+k}} \right)^{-\varepsilon_{hM}} Y_{t+k} - MC_{t+k}^n \left(\frac{\bar{P}_{hM,t}}{P_{hM,t+k}} \right)^{-\varepsilon_{hM}} Y_{t+k} \right]$$

$$V = \sum_{k=0}^{\infty} \theta^k E_t Q_{t,t+k} \left[\frac{\bar{P}_{hM,t}^{1-\varepsilon_{hM}}}{P_{hM,t+k}^{-\varepsilon_{hM}}} Y_{t+k} - MC_{t+k}^n \frac{\bar{P}_{hM,t}^{-\varepsilon_{hM}}}{P_{hM,t+k}^{-\varepsilon_{hM}}} Y_{t+k} \right]$$

$$\frac{\partial V}{\partial \bar{P}_{hM,t}} = \sum_{k=0}^{\infty} \theta^k E_t Q_{t,t+k} \left[(1 - \varepsilon) \frac{\bar{P}_{hM,t}^{-\varepsilon_{hM}}}{P_{hM,t+k}^{-\varepsilon_{hM}}} Y_{t+k} + \varepsilon_{hM} MC_{t+k}^n \frac{\bar{P}_{hM,t}^{-\varepsilon_{hM}-1}}{P_{hM,t+k}^{-\varepsilon_{hM}}} Y_{t+k} \right] = 0$$

Recall $Q_{t,t+k} = \beta^k \left(\frac{C_{t+k}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+k}} \right)$ from household derivation, then

$$\frac{\partial V}{\partial \bar{P}_{hM,t}} = \frac{P_t}{C_t^{-\sigma}} \sum_{k=0}^{\infty} \theta^k E_t \beta^k \left(\frac{C_{t+k}}{P_{t+k}} \right)^{-\sigma} Y_{t+k}^d \left[\bar{P}_{hM,t} - \frac{\varepsilon_{hM}}{(\varepsilon_{hM} - 1)} MC_{t+k}^n \right] = 0$$

since its index is not t but k then we can get rid off P_t and C_t

$$\frac{\partial V}{\partial \bar{P}_{hM,t}} = \sum_{k=0}^{\infty} \theta^k E_t \beta^k C_{t+k}^{-\sigma} P_{t+k}^{-1} Y_{t+k}^d \left[\bar{P}_{hM,t} - \frac{\varepsilon_{hM}}{(\varepsilon_{hM} - 1)} MC_{t+k}^n \right] = 0$$

Multiplied by $\frac{P_{hM,t-1}}{P_{hM,t-1}}$

$$\frac{\partial V}{\partial \bar{P}_{hM,t}} = \sum_{k=0}^{\infty} (\beta\theta)^k E_t \left\{ C_{t+k}^{-\sigma} Y_{t+k}^d \frac{P_{hM,t-1}}{P_{t+k}} \left[\frac{\bar{P}_{hM,t}}{P_{hM,t-1}} - \frac{\varepsilon_{hM}}{(\varepsilon_{hM} - 1)} \Pi_{t-1,t+k}^M MC_{t+k} \right] \right\} = 0$$

Where $\Pi_{t-1,t+k}^M = \frac{P_{hM,t+k}}{P_{hM,t-1}}$ and $MC_{t+k} = \frac{MC_{t+k}^n}{P_{hM,t+k}}$

$$\begin{aligned} \bar{P}_{hM,t} \sum_{k=0}^{\infty} (\beta\theta)^k E_t \left\{ C_{t+k}^{-\sigma} \frac{Y_{t+k}^d}{P_{t+k}} \right\} \\ = \frac{\varepsilon_{hM}}{(\varepsilon_{hM} - 1)} P_{hM,t-1} \sum_{k=0}^{\infty} (\beta\theta)^k E_t \left\{ C_{t+k}^{-\sigma} \frac{Y_{t+k}^d}{P_{t+k}} \Pi_{t-1,t+k}^M MC_{t+k} \right\} \\ \bar{P}_{hM,t} \sum_{k=0}^{\infty} (\beta\theta)^k \Gamma_{t+k} = \frac{\varepsilon_{hM}}{(\varepsilon_{hM} - 1)} P_{hM,t-1} \sum_{k=0}^{\infty} (\beta\theta)^k \Gamma_{t+k} \Pi_{t-1,t+k}^M MC_{t+k} \end{aligned} \quad (4A.27)$$

Identities

The effective **terms of trade** is defined by

$$S_t = \left(\int_0^1 S_{i,t}^{1-\gamma} di \right)^{\frac{1}{1-\gamma}} = \frac{P_{f,t}}{P_{h,t}} \quad (4A.28)$$

It is assumed that the **Law of One Price** holds in this model

$$P_{i,t} = P_{i,t}^i \mathcal{E}_{i,t} \quad (4A.29)$$

where $\mathcal{E}_{i,t}$ is the bilateral nominal exchange rate.

The bilateral **real exchange rate** is defined by

$$\Omega_{i,t} = \frac{\mathcal{E}_{i,t} P_t^i}{P_t} \quad (4A.30)$$

The Link between domestic and foreign consumption

From the household derivation we have $\beta \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) = Q_{t,t+1}$. This characteristic is also assumed for each country i . Accounting for the exchange rate, the characteristic of each country in terms of domestic currency can be rewritten as follows:

$$\beta \left(\frac{C_{t+1}^i}{C_t^i} \right)^{-\sigma} \left(\frac{P_t^i \mathcal{E}_{i,t}}{P_{t+1}^i \mathcal{E}_{i,t+1}} \right) = Q_{t,t+1} \quad (4A.31)$$

Equating this equation for both domestic and foreign country in terms of $Q_{t,t+1}$ we get

$$\beta \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) = \beta \left(\frac{C_{t+1}^i}{C_t^i} \right)^{-\sigma} \left(\frac{P_t^i \mathcal{E}_{i,t}}{P_{t+1}^i \mathcal{E}_{i,t+1}} \right)$$

$$\left(\frac{C_{t+1}}{C_{t+1}^i}\right)^{-\sigma} \left(\frac{P_{t+1}^i}{P_{t+1}}\right) \varepsilon_{i,t+1} = \left(\frac{C_t}{C_t^i}\right)^{-\sigma} \left(\frac{P_t^i}{P_t}\right) \varepsilon_{i,t}$$

Given that, this identity is also hold

$$\left(\frac{C_{t+1}}{C_{t+1}^i}\right)^{-\sigma} \left(\frac{P_{t+1}^i}{P_{t+1}}\right) \varepsilon_{i,t+1} = \left(\frac{C_t}{C_t^i}\right)^{-\sigma} \left(\frac{P_t^i}{P_t}\right) \varepsilon_{i,t+1} = \left(\frac{C_0}{C_0^i}\right)^{-\sigma} \left(\frac{P_0^i}{P_0}\right) \varepsilon_{i,t} = Y = Y_i = 1$$

The last part is the initial consumption ratio, which is assumed to be identical for each country (symmetric initial condition). Let this ratio is equal to 1. Given equation (4A.29) we get,

$$\left(\frac{C_t}{C_t^i}\right)^{-\sigma} \left(\frac{P_t^i}{P_t}\right) \varepsilon_{i,t} = 1$$

$$C_t = C_t^i \Omega_{i,t}^{\frac{1}{\sigma}} \quad (4A.32)$$

Uncovered Interest Parity

The price of riskless bond denominated in foreign currency:

$$\varepsilon_{i,t} (R_t^i)^{-1} = E_t \{Q_{t,t+1} \varepsilon_{i,t+1}\} \quad (4A.33)$$

while that of the domestic bond is as follows:

$$(R_t)^{-1} = E_t \{Q_{t,t+1}\} \quad (4A.34)$$

Recall that $Q_{t,t+1}$ is stochastic discount factor of one period nominal pay off of asset hold. In equilibrium it is the same as the gross return of real interest rate:

$$R_t = \frac{1}{E_t \{Q_{t,t+1}\}}$$

Assuming complete international financial market, we can equalize the two equations,

$$\frac{R_t^i}{\varepsilon_{i,t}} E_t \{Q_{t,t+1} \varepsilon_{i,t+1}\} = R_t E_t \{Q_{t,t+1}\} \quad (4A.35)$$

$$E_t \left\{ Q_{t,t+1} \left[R_t - R_t^i \frac{\varepsilon_{i,t+1}}{\varepsilon_{i,t}} \right] \right\} = 0 \quad (4A.36)$$

Equilibrium

Given the two sectors, we shall have two equilibriums in good markets: in non-food and food market. Here we derive the equilibrium in non-food market. For food market, the equilibrium is identical. Total output of domestic non-food firms is equal to domestic consumption and foreign consumption or export.

$$Y_{hM,t}(j) = C_{hM,t}(j) + \int_0^1 C_{hM,t}^i(j) di$$

$$\text{given } C_{f,t} = \alpha \left(\frac{P_{f,t}}{P_t} \right)^{-\eta} C_t \quad C_{hM,t}(j) = \left(\frac{P_{hM,t}(j)}{P_{hM,t}} \right)^{-\varepsilon_{hM}} C_{hM,t}$$

$$C_{h,t} = (1 - \alpha) \left(\frac{P_{h,t}}{P_t} \right)^{-\eta} C_t \quad C_{i,t} = \left(\frac{P_{i,t}}{P_{f,t}} \right)^{-\gamma} C_{f,t}$$

$$Y_{hM,t}(j) = \left(\frac{P_{hM,t}(j)}{P_{hM,t}} \right)^{-\varepsilon_{hM}} C_{hM,t} + \int_0^1 \left(\frac{P_{hM,t}^i(j)}{P_{hM,t}^i} \right)^{-\varepsilon_{hM}} C_{hM,t}^i di$$

$$Y_{hM,t}(j) = \left(\frac{P_{hM,t}(j)}{P_{hM,t}} \right)^{-\varepsilon_{hM}} (1 - \alpha_3) \left(\frac{P_{hM,t}}{P_{h,t}} \right)^{-\kappa} C_{h,t} \\ + (1 - \alpha_3) \int_0^1 \left(\frac{P_{hM,t}^i(j)}{P_{hM,t}^i} \right)^{-\varepsilon_{hM}} \left(\frac{P_{hM,t}^i}{P_{h,t}^i} \right)^{-\kappa} C_{h,t}^i di$$

$$Y_{hM,t}(j) = \left(\frac{P_{hM,t}(j)}{P_{hM,t}} \right)^{-\varepsilon_{hM}} \left[(1 - \alpha_3) \left(\frac{P_{hM,t}}{P_{h,t}} \right)^{-\kappa} (1 - \alpha) \left(\frac{P_{h,t}}{P_t} \right)^{-\eta} C_t + \right. \\ \left. (1 - \alpha_3) \alpha \int_0^1 \left(\frac{P_{hM,t}^i}{P_{h,t}^i} \right)^{-\kappa} \left(\frac{P_{f,t}^i}{P_t^i} \right)^{-\eta} \left(\frac{P_{h,t}}{\varepsilon_{i,t} P_{f,t}^i} \right)^{-\gamma} C_t^i di \right] \quad (4A.37)$$

The aggregate domestic non-food output equation is

$$Y_{hM,t} = \left[\int_0^1 Y_{hM,t}(j)^{\frac{\varepsilon_{hM}}{\varepsilon_{hM}-1}} dj \right]^{\frac{\varepsilon_{hM}}{\varepsilon_{hM}-1}}, \text{ plug equation (4A.37) into this to get}$$

$$Y_{hM,t} = \left[\int_0^1 \left(\left(\frac{P_{hM,t}(j)}{P_{hM,t}} \right)^{-\varepsilon_{hM}} \left[(1 - \alpha_3) \left(\frac{P_{hM,t}}{P_{h,t}} \right)^{-\kappa} (1 - \alpha) \left(\frac{P_{h,t}}{P_t} \right)^{-\eta} C_t \right. \right. \right. \\ \left. \left. \left. + (1 - \alpha_3) \alpha \int_0^1 \left(\frac{P_{hM,t}^i}{P_{h,t}^i} \right)^{-\kappa} \left(\frac{P_{f,t}^i}{P_t^i} \right)^{-\eta} \left(\frac{P_{h,t}}{\varepsilon_{i,t} P_{f,t}^i} \right)^{-\gamma} C_t^i di \right] \right)^{\frac{\varepsilon_{hM}-1}{\varepsilon_{hM}}} dj \right]^{\frac{\varepsilon_{hM}}{\varepsilon_{hM}-1}}$$

$$\text{As } P_{hM,t} \equiv \left[\int_0^1 P_{hM,t}(j)^{1-\varepsilon_{hM}} dj \right]^{\frac{1}{1-\varepsilon_{hM}}}$$

$$\left[\int_0^1 \left(\left(\frac{P_{hM,t}(j)}{P_{hM,t}} \right)^{-\varepsilon_{hM}} \right)^{\frac{\varepsilon_{hM}-1}{\varepsilon_{hM}}} dj \right]^{\frac{\varepsilon_{hM}}{\varepsilon_{hM}-1}} = \left[\frac{1}{\int_0^1 P_{hM,t}(j)^{1-\varepsilon_{hM}} dj} \int_0^1 (P_{hM,t}(j))^{1-\varepsilon_{hM}} dj \right]^{\frac{\varepsilon_{hM}}{\varepsilon_{hM}-1}} = 1$$

$$Y_{hM,t} = (1 - \alpha)(1 - \alpha_3) \left(\frac{P_{hM,t}}{P_{h,t}} \right)^{-\kappa} \left(\frac{P_{h,t}}{P_t} \right)^{-\eta} C_t \\ + (1 - \alpha_3) \alpha \int_0^1 \left(\frac{P_{hM,t}^i}{P_{h,t}^i} \right)^{-\kappa} \left(\frac{P_{f,t}^i}{P_t^i} \right)^{-\eta} \left(\frac{P_{h,t}}{\varepsilon_{i,t} P_{f,t}^i} \right)^{-\gamma} C_t^i di$$

$$Y_{hM,t} = \left(\frac{P_{h,t}}{P_t}\right)^{-\eta} \left[(1-\alpha)(1-\alpha_3) \left(\frac{P_{hM,t}}{P_{h,t}}\right)^{-\kappa} C_t \right. \\ \left. + \alpha(1-\alpha_3) \int_0^1 \left(\frac{P_{hM,t}^i}{P_{h,t}^i}\right)^{-\kappa} \left(\frac{\varepsilon_{i,t} P_{f,t}^i}{P_{h,t}}\right)^{\gamma-\eta} \left(\frac{\varepsilon_{i,t} P_t^i}{P_t}\right)^{\eta} C_t^i di \right]$$

We have $\Omega_{i,t} = \frac{\varepsilon_{i,t} P_t^i}{P_t}$ and $C_t = C_t^i \Omega_{i,t}^{\frac{1}{\sigma}}$, we use these to get

$$Y_{hM,t} = \left(\frac{P_{h,t}}{P_t}\right)^{-\eta} \left[(1-\alpha)(1-\alpha_3) \left(\frac{P_{hM,t}}{P_{h,t}}\right)^{-\kappa} C_t \right. \\ \left. + \alpha(1-\alpha_3) \int_0^1 \left(\frac{P_{hM,t}^i}{P_{h,t}^i}\right)^{-\kappa} \left(\frac{P_{i,t}}{P_{h,t}} \frac{\varepsilon_{i,t} P_{f,t}^i}{P_{h,t}}\right)^{\gamma-\eta} \Omega_{i,t}^{\eta-\frac{1}{\sigma}} C_t di \right]$$

$$\text{As } S_t = \frac{P_{f,t}}{P_{h,t}} \text{ then } S_t^i = \frac{\varepsilon_{i,t} P_{f,t}^i}{P_{i,t}} \quad \text{and} \quad S_{i,t} = \frac{P_{i,t}}{P_{h,t}}$$

Where S_t is the effective terms of trade of home country, S_t^i is the effective terms of trade of country i and $S_{i,t}$ is bilateral terms of trade between home economy and country i .

$$Y_{hM,t} = \left(\frac{P_{h,t}}{P_t}\right)^{-\eta} C_t \left[(1-\alpha)(1-\alpha_3) \left(\frac{P_{hM,t}}{P_{h,t}}\right)^{-\kappa} \right. \\ \left. + \alpha(1-\alpha_3) \int_0^1 (S_{i,t} S_t^i)^{\gamma-\eta} \left(\frac{P_{hM,t}^i}{P_{h,t}^i}\right)^{-\kappa} \Omega_{i,t}^{\eta-\frac{1}{\sigma}} di \right]$$

As $P_t = [(1-\alpha)P_{h,t}^{1-\eta} + \alpha P_{f,t}^{1-\eta}]^{\frac{1}{1-\eta}}$, we can approach $P_t = P_{h,t}^{1-\alpha} P_{f,t}^{\alpha}$ so that $\left(\frac{P_{h,t}}{P_t}\right) = \left(\frac{P_{h,t}}{P_{f,t}}\right)^{\alpha}$ remember also $S_t = \frac{P_{f,t}}{P_{h,t}}$

$$Y_{hM,t} = \left(\frac{P_{h,t}}{P_{f,t}}\right)^{-\alpha\eta} C_t \left[(1-\alpha)(1-\alpha_3) \left(\frac{P_{hM,t}}{P_{h,t}}\right)^{-\kappa} \right. \\ \left. + \alpha(1-\alpha_3) \int_0^1 (S_{i,t} S_t^i)^{\gamma-\eta} \left(\frac{P_{hM,t}^i}{P_{h,t}^i}\right)^{-\kappa} \Omega_{i,t}^{\eta-\frac{1}{\sigma}} di \right]$$

$$Y_{hM,t} = S_t^{\alpha\eta} C_t \left[(1-\alpha)(1-\alpha_3) \left(\frac{P_{hM,t}}{P_{h,t}}\right)^{-\kappa} \right. \\ \left. + \alpha(1-\alpha_3) \int_0^1 (S_{i,t} S_t^i)^{\gamma-\eta} \left(\frac{P_{hM,t}^i}{P_{h,t}^i}\right)^{-\kappa} \Omega_{i,t}^{\eta-\frac{1}{\sigma}} di \right]$$

As $\Omega_{i,t} = \frac{\varepsilon_{i,t} P_t^i}{P_t}$ and $\Omega_{i,t} = \frac{\varepsilon_{i,t} P_{hM,t}^i}{P_{hM,t}}$, we get the **demand for domestic non-foods goods**:

$$Y_{hM,t} = S_t^{\alpha\eta} P_{hM,t}^{-\kappa} P_{h,t}^{\kappa} C_t (1-\alpha)(1-\alpha_3) +$$

$$S_t^{\alpha\eta} P_{hM,t}^{-\kappa} P_{h,t}^{\kappa} \alpha(1 - \alpha_3) C_t \int_0^1 (S_{i,t} S_t^i)^{\gamma-\eta} \Omega_{i,t}^{\eta-\frac{1}{\sigma}} di \quad (4A.38)$$

Analogously for the **demand for domestic food goods**:

$$Y_{hM,t} = S_t^{\alpha\eta} P_{hF,t}^{-\kappa} P_{h,t}^{\kappa} C_t (1 - \alpha)(1 - \alpha_3) +$$

$$S_t^{\alpha\eta} P_{hF,t}^{-\kappa} P_{h,t}^{\kappa} \alpha(1 - \alpha_3) C_t \int_0^1 (S_{i,t} S_t^i)^{\gamma-\eta} \Omega_{i,t}^{\eta-\frac{1}{\sigma}} di \quad (4A.39)$$

One source of perturbation in this model is technology shocks that influence the real variables. The technology follows a unit root process.

$$\ln A_t = \ln A_{t-1} + \epsilon_{A,t} \quad (4A.40)$$

Stationarising the Models

As some variables in the model are non stationary, we stationarize the model following Justiniano et al. (2009) as follows:

$\hat{C} = \frac{C}{A}$, $\hat{Y}_{hM} = \frac{Y_{hM}}{A}$, $\hat{Y}_{hF} = \frac{Y_{hF}}{A}$, $\hat{Y} = \frac{Y}{A}$, $\hat{P} = \frac{\bar{P}}{P}$, where \bar{P} is a type of price such as domestic fuel price, foreign price and so on.

Hence some relevant equations in the model will be transformed as follows:

$$\beta R_t E_t \left\{ \left(\frac{\hat{C}_{t+1} \hat{A}_{t+1}}{\hat{C}_t \hat{A}_t} \right)^{-\sigma} \left(\frac{1}{\pi_{t+1}} \right) \right\} = 1 \quad (4A.41)$$

$$P_t = [(1 - \alpha) \hat{P}_{h,t}^{1-\eta} + \alpha \hat{P}_{f,t}^{1-\eta}]^{\frac{1}{1-\eta}} \quad (4A.42)$$

$$\hat{P}_{f,t} = [(1 - \alpha_1 - \alpha_2) \hat{P}_{fM,t}^{1-v} + \alpha_1 \hat{P}_{O,t}^{1-v} + \alpha_2 \hat{P}_{fF,t}^{1-v}]^{\frac{1}{1-v}} \quad (4A.43)$$

$$\hat{P}_{h,t} = [(1 - \alpha_3) \hat{P}_{hM,t}^{1-\kappa} + \alpha_3 \hat{P}_{hF,t}^{1-\kappa}]^{\frac{1}{1-\kappa}} \quad (4A.44)$$

$$\sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \left\{ \hat{W}_t \Gamma_{t+k} \right\} = \frac{\varepsilon_w}{\varepsilon_w - 1} \hat{W}_{t-1} \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t \left\{ \Gamma_{t+k} MRS_{t+k} \frac{\hat{P}_{t+k}}{\hat{W}_{t+k}} \Pi_{t-1,t+k} \right\} \quad (4A.45)$$

$$N_{hM,t} = \left(\frac{\hat{P}_{O,t} \phi}{\hat{W}_t (1-\phi)} \right)^{1-\phi} \hat{Y}_{hM,t} \quad (4A.46)$$

$$N_{hF,t} = \left(\frac{\hat{P}_{L,t} \phi_L}{\hat{W}_t (1-\phi_L)} \right)^{1-\phi_L} \hat{Y}_{hF,t} \quad (4A.47)$$

$$MC_{hM,t} = \frac{1}{\hat{P}_{hM,t}} \hat{P}_{O,t}^{1-\phi} \hat{W}_t^{\phi} \left(\frac{1}{1-\phi} \right) \left(\frac{1-\phi}{\phi} \right)^{\phi} \quad (4A.48)$$

$$MC_{hF,t} = \frac{1}{\hat{P}_{hF,t}} \hat{P}_{L,t}^{1-\phi_L} \hat{W}_t^{\phi} \left(\frac{1}{1-\phi_L} \right) \left(\frac{1-\phi_L}{\phi_L} \right)^{\phi_L} \quad (4A.49)$$

$$\hat{P}_{hM,t} \sum_{k=0}^{\infty} (\beta\theta)^k \Gamma_{t+k} = \frac{\varepsilon_{hM}}{(\varepsilon_{hM}-1)} \hat{P}_{hM,t-1} \sum_{k=0}^{\infty} (\beta\theta)^k \Gamma_{t+k} \Pi_{t-1,t+k}^M MC_{t+k} \quad (4A.50)$$

$$\hat{P}_{hF,t} \sum_{k=0}^{\infty} (\beta\theta)^k \Gamma_{t+k} = \frac{\varepsilon_{hF}}{(\varepsilon_{hF}-1)} \hat{P}_{hF,t-1} \sum_{k=0}^{\infty} (\beta\theta)^k \Gamma_{t+k} \Pi_{t-1,t+k}^M MC_{t+k} \quad (4A.51)$$

$$\begin{aligned} \hat{Y}_{hM,t} &= S_t^{\alpha\eta} \hat{P}_{hM,t}^{-\kappa} \hat{P}_{h,t}^{\kappa} \hat{C}_t (1-\alpha)(1-\alpha_3) + \\ &S_t^{\alpha\eta} \hat{P}_{hM,t}^{-\kappa} \hat{P}_{h,t}^{\kappa} \alpha(1-\alpha_3) \hat{C}_t \int_0^1 (S_{i,t} S_t^i)^{\gamma-\eta} \Omega_{i,t}^{\eta-\frac{1}{\sigma}} di \end{aligned} \quad (4A.52)$$

$$\begin{aligned} \hat{Y}_{hF,t} &= S_t^{\alpha\eta} \hat{P}_{hF,t}^{-\kappa} \hat{P}_{h,t}^{\kappa} \hat{C}_t (1-\alpha)(1-\alpha_3) + \\ &S_t^{\alpha\eta} \hat{P}_{hF,t}^{-\kappa} \hat{P}_{h,t}^{\kappa} \alpha(1-\alpha_3) \hat{C}_t \int_0^1 (S_{i,t} S_t^i)^{\gamma-\eta} \Omega_{i,t}^{\eta-\frac{1}{\sigma}} di \end{aligned} \quad (4A.53)$$

Steady State Level

Given (4A.41)

$$\beta = \frac{1}{R}$$

Given (4A.42), (4A.43), and (4A.44)

$$P = P_h = P_f = P_{hM} = P_{hF} = P_{hM} = P_{hF} = P_{fM} = P_{fF} = P_o = W$$

Given (4A.45), (4A.46), and (4A.47)

$$\begin{aligned} \frac{\varepsilon_w - 1}{\varepsilon_w} &= MRS \\ \frac{\varepsilon_{hM} - 1}{\varepsilon_{hM}} &= MC_{hM} \\ \frac{\varepsilon_{hF} - 1}{\varepsilon_{hF}} &= MC_{hF} \end{aligned}$$

Given (4A.46) and (4A.47)

$$\begin{aligned} Y_{hM} &= AN_{hM} \\ Y_{hF} &= AN_{hF} \\ N &= N_{hM} + N_{hF} \\ Y &= AN \\ \frac{N_{hM}}{N} &= \frac{Y_{hM}}{Y} \end{aligned}$$

$$\frac{N_{hF}}{N} = \frac{Y_{hF}}{Y}$$

Given (4A.28), (4A.29), and (4A.30)

$$S = \mathcal{E} = \Omega = 1$$

Given (4A.52) and (4A.53)

$$Y_{hM} = (1 - \alpha_3)S^{\alpha\eta}C$$

$$Y_{hF} = \alpha_3 S^{\alpha\eta}C$$

$$Y = Y_{hM} + Y_{hF}$$

$$Y = C$$

$$\frac{Y_{hM}}{Y} = (1 - \alpha_3)$$

Log Linearisation Around Steady State

The variable in log linearize around its steady state is denoted by tilde. For example $\tilde{y}_t = \log(Y_t) - \log(Y)$. The variable with hat is simplified by taking out the hat.

Households' consumption

$$\beta R_t E_t \left\{ \left(\frac{\tilde{C}_{t+1} A_{t+1}}{\tilde{C}_t A_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) \right\} = 1$$

$$\text{Let } a_{t+1} = \log \left(\frac{A_{t+1}}{A_t} \right)$$

$$C^{-\sigma} e^{-\sigma \tilde{c}_t} = \beta e^{\tilde{\beta}_t} R e^{\tilde{r}_t} C^{-\sigma} e^{-\sigma \tilde{c}_{t+1}} a^{-\sigma} e^{-\sigma \tilde{a}_{t+1}} P e^{\tilde{p}_t} P^{-1} e^{-\tilde{p}_{t+1}}$$

$$(1 - \sigma \tilde{c}_t) = \beta R (1 + \tilde{\beta}_t + \tilde{r}_t - \sigma E_t(\tilde{c}_{t+1}) - \sigma E_t(\tilde{a}_{t+1}) + \tilde{p}_t - E_t(\tilde{p}_{t+1}))$$

From the steady state we find $\beta = \frac{1}{R}$. Hence

$$\sigma \tilde{c}_t = \sigma E_t(\tilde{c}_{t+1}) + \sigma E_t(\tilde{a}_{t+1}) - \tilde{r}_t + E(\tilde{p}_{t+1}) - \tilde{p}_t$$

$$\tilde{c}_t = E(\tilde{c}_{t+1}) + E_t(\tilde{a}_{t+1}) - \frac{1}{\sigma} [\tilde{r} - E(\tilde{\pi}_{t+1})] \quad (4A.54)$$

Consumer Price Index

$$P_t = [(1 - \alpha)P_{h,t}^{1-\eta} + \alpha P_{f,t}^{1-\eta}]^{\frac{1}{1-\eta}}$$

$$\tilde{p}_t = \frac{1}{Z} [(1 - \alpha)P_h^{1-\eta} \tilde{p}_{h,t} + \alpha P_f^{1-\eta} \tilde{p}_{f,t}] \text{ where } Z = (1 - \alpha)P_{h,t}^{1-\eta} + \alpha P_{f,t}^{1-\eta}$$

At steady state $P = P_h = P_f$ hence $Z = P_h^{1-\eta} = P_f^{1-\eta}$

$$\tilde{p}_t \approx (1 - \alpha)\tilde{p}_{h,t} + \alpha\tilde{p}_{f,t}$$

$$\pi_t \approx (1 - \alpha)\pi_{h,t} + \alpha\pi_{f,t} \quad (4A.55)$$

Foreign Price Index

$$P_{f,t} = \left[(1 - \alpha_1 - \alpha_2)P_{fM,t}^{1-\nu} + \alpha_1 P_{O,t}^{1-\nu} + \alpha_2 P_{fF,t}^{1-\nu} \right]^{\frac{1}{1-\nu}}$$

Log linearization the above equation yields

$$\begin{aligned} \tilde{p}_{f,t} &\approx (1 - \alpha_1 - \alpha_2)\tilde{p}_{fM,t} + \alpha_1\tilde{p}_{O,t} + \alpha_2\tilde{p}_{fF,t} \\ \pi_{f,t} &\approx (1 - \alpha_1 - \alpha_2)\pi_{fM,t} + \alpha_1\pi_{O,t} + \alpha_2\pi_{fF,t} \end{aligned} \quad (4A.56)$$

Analogously for the other type of price.

Domestic Price Index

$$\begin{aligned} \tilde{p}_{h,t} &\approx (1 - \alpha_3)\tilde{p}_{hM,t} + \alpha_3\tilde{p}_{hF,t} \\ \pi_{h,t} &\approx (1 - \alpha_3)\pi_{hM,t} + \alpha_3\pi_{hF,t} \end{aligned} \quad (4A.57)$$

We define core price as prices that consist of prices of domestic non-food prices as well as imported non-food prices. Meanwhile, non-core prices consist of imported oil prices and both domestic and imported food prices. Using these definitions and the combination of equation (4A.9), (4A.15), and (4A.16) we get the approximation of core and non-core price as follows:

$$\pi_{c,t} \approx (1 - \alpha)(1 - \alpha_3)\pi_{hM,t} + \alpha(1 - \alpha_1 - \alpha_2)\pi_{fM,t} \quad (4A.58)$$

$$\pi_{nc,t} \approx (1 - \alpha)\alpha_3\pi_{hF,t} + \alpha\alpha_1\pi_{O,t} + \alpha\alpha_2\pi_{fF,t} \quad (4A.59)$$

Nominal wage inflation

The optimum wage is determined by this equation

$$\sum_{k=0}^{\infty} (\beta\theta_w)^k E_t \{ \bar{W}_t \Gamma_{t+k} \} = \frac{\varepsilon_w}{\varepsilon_w - 1} W_{t-1} \sum_{k=0}^{\infty} (\beta\theta_w)^k E_t \left\{ \Gamma_{t+k} MRS_{t+k} \frac{P_{t+k}}{W_{t+k}} \Pi_{t-1,t+k} \right\}$$

We log linearize this equation. The LHS of this equation can be rewritten:

$$\begin{aligned} &= \sum_{k=0}^{\infty} (\beta\theta_w)^k \Gamma_{t+k} \bar{W}_t \\ &= \sum_{k=0}^{\infty} (\beta\theta_w)^k \Gamma e^{\tilde{\Gamma}_{t+k}} \bar{W} e^{\tilde{\bar{W}}_t} \\ &= \sum_{k=0}^{\infty} (\beta\theta_w)^k \bar{W} \Gamma e^{\tilde{\Gamma}_{t+k} + \tilde{\bar{W}}_t} \\ &= \sum_{k=0}^{\infty} (\beta\theta_w)^k \bar{W} \Gamma E_t (1 + \tilde{\Gamma}_{t+k} + \tilde{\bar{W}}_t) \\ &= \frac{\Gamma \bar{W}}{1 - \beta\theta_w} (1 + \tilde{\bar{W}}_t) + \Gamma \bar{W} \sum_{k=0}^{\infty} (\beta\theta_w)^k E_t (\tilde{\Gamma}_{t+k}) \end{aligned}$$

We can write the RHS:

$$\begin{aligned}
&= \frac{\varepsilon_w}{(\varepsilon_w - 1)} \sum_{k=0}^{\infty} (\beta \theta_w)^k W e^{\tilde{w}_{t-1}} \Gamma e^{\tilde{r}_{t+k}} MRS e^{\tilde{m} \tilde{r}_{t+k}} P e^{\tilde{p}_{t+k}} \Pi e^{\tilde{\pi}_{t-1,t+k}} W^{-1} e^{-\tilde{w}_{t+k}} \\
&= \frac{\varepsilon_w}{(\varepsilon_w - 1)} \Gamma MRS P \Pi \sum_{k=0}^{\infty} (\beta \theta_w)^k (e^{\tilde{r}_{t+k} + \tilde{m} \tilde{r}_{t+k} + \tilde{p}_{t+k} + \tilde{w}_{t-1} - \tilde{w}_{t+k} + \tilde{\pi}_{t-1,t+k}}) \\
&= \frac{\varepsilon_w}{(\varepsilon_w - 1)} \Gamma MRS P \Pi \sum_{k=0}^{\infty} (\beta \theta_w)^k (1 + \tilde{w}_{t-1} + \tilde{r}_{t+k} + \tilde{\pi}_{t-1,t+k} + \tilde{m} \tilde{r}_{t+k} + \tilde{p}_{t+k} - \tilde{w}_{t+k})
\end{aligned}$$

Note in steady state we have

$$\begin{aligned}
\bar{W} &= \frac{\varepsilon_w}{(\varepsilon_w - 1)} \frac{W \sum_{k=0}^{\infty} (\beta \theta_w)^k \Gamma MRS P \Pi}{\sum_{k=0}^{\infty} (\beta \theta_w)^k \Gamma} \\
\frac{\varepsilon_w}{(\varepsilon_w - 1)} &= \frac{\bar{W}}{MRS P \Pi}
\end{aligned}$$

So that RHS becomes,

$$\begin{aligned}
&= \Gamma \bar{W} \sum_{k=0}^{\infty} (\beta \theta_w)^k (1 + \tilde{w}_{t-1} + \tilde{r}_{t+k} + \tilde{\pi}_{t-1,t+k} + \tilde{m} \tilde{r}_{t+k} + \tilde{p}_{t+k} - \tilde{w}_{t+k}) \\
&= \bar{W} \Gamma \frac{1}{1 - \beta \theta_w} (1 + \tilde{w}_{t-1}) + \bar{W} \Gamma \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t(\tilde{r}_{t+k} + \tilde{\pi}_{t-1,t+k} + \tilde{m} \tilde{r}_{t+k} + \tilde{p}_{t+k} - \tilde{w}_{t+k})
\end{aligned}$$

Equalize LHS and RHS, we get

$$\begin{aligned}
&\frac{\Gamma \bar{W}}{1 - \beta \theta_w} (1 + \tilde{w}_t) + \Gamma \bar{W} \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t(\tilde{r}_{t+k}) = \\
&\frac{\bar{W} \Gamma}{1 - \beta \theta_w} (1 + \tilde{w}_{t-1}) + \bar{W} \Gamma \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t(\tilde{r}_{t+k} + \tilde{\pi}_{t-1,t+k} + \tilde{m} \tilde{r}_{t+k} + \tilde{p}_{t+k} - \tilde{w}_{t+k}) \\
&\tilde{w}_t - \tilde{w}_{t-1} = (1 - \beta \theta_w) \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t(\tilde{\pi}_{t-1,t+k} + \tilde{m} \tilde{r}_{t+k} + \tilde{p}_{t+k} - \tilde{w}_{t+k}) \quad (4A.60) \\
&\tilde{w}_t - \tilde{w}_{t-1} = (1 - \beta \theta_w) \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t(\tilde{w}_{t+k} - \tilde{w}_{t-1} + \tilde{m} \tilde{r}_{t+k} + \tilde{p}_{t+k} - \tilde{w}_{t+k}) \\
&\tilde{w}_t - \tilde{w}_{t-1} = (1 - \beta \theta_w)(\tilde{m} \tilde{r}_t + \tilde{p}_t - \tilde{w}_t + \tilde{w}_t - \tilde{w}_{t-1}) + (1 - \beta \theta_w) \sum_{k=1}^{\infty} (\beta \theta_w)^k E_t(\tilde{w}_{t+k} - \tilde{w}_t + \tilde{w}_t - \tilde{w}_{t-1} + \tilde{m} \tilde{r}_{t+k} + \tilde{p}_{t+k} - \tilde{w}_{t+k}) \\
&\tilde{w}_t - \tilde{w}_{t-1} = (1 - \beta \theta_w)(\tilde{m} \tilde{r}_t + \tilde{p}_t - \tilde{w}_t + \tilde{\pi}_t^w) + (1 - \beta \theta_w) \beta \theta_w \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t(\tilde{w}_{t+k+1} - \tilde{w}_t + \tilde{w}_t - \tilde{w}_{t-1} + \tilde{m} \tilde{r}_{t+k+1} + \tilde{p}_{t+k+1} - \tilde{w}_{t+k+1}) \\
&\tilde{w}_t - \tilde{w}_{t-1} = (1 - \beta \theta_w)(\tilde{m} \tilde{r}_t + \tilde{p}_t - \tilde{w}_t + \tilde{\pi}_t^w) + (1 - \beta \theta_w) \beta \theta_w \sum_{k=0}^{\infty} (\beta \theta_w)^k E_t(\tilde{w}_{t+k+1} - \tilde{w}_t + \tilde{m} \tilde{r}_{t+k+1} + \tilde{p}_{t+k+1} - \tilde{w}_{t+k+1}) \\
&\quad + \frac{(1 - \beta \theta_w) \beta \theta_w}{(1 - \beta \theta_w)} (\tilde{w}_t - \tilde{w}_{t-1})
\end{aligned}$$

$$\begin{aligned} \tilde{w}_t - \tilde{w}_{t-1} = & (1 - \beta\theta_w)(\tilde{m}r s_t + \tilde{p}_t - \tilde{w}_t) + \tilde{\pi}_t^w + (1 - \beta\theta_w)\beta\theta_w \sum_{k=0}^{\infty} (\beta\theta_w)^k E_t(\tilde{w}_{t+k+1} - \tilde{w}_t + \\ & \tilde{m}r s_{t+k+1} + \tilde{p}_{t+k+1} - \tilde{w}_{t+k+1}) \end{aligned} \quad (4A.61)$$

From (4A.60), we can get its expectation

$$\begin{aligned} E_t(\tilde{w}_{t+1} - \tilde{w}_t) = & (1 - \beta\theta_w) \\ & \sum_{k=0}^{\infty} (\beta\theta_w)^k E_t(\tilde{w}_{t+k+1} - \tilde{w}_t + \tilde{m}r s_{t+k+1} + \tilde{p}_{t+k+1} - \tilde{w}_{t+k+1}) \end{aligned}$$

Plug this into (4A.61) yields

$$\tilde{w}_t - \tilde{w}_{t-1} = (1 - \beta\theta_w)(\tilde{m}r s_t + \tilde{p}_t - \tilde{w}_t) + \tilde{\pi}_t^w + \beta\theta_w E_t(\tilde{w}_{t+1} - \tilde{w}_t) \quad (4A.62)$$

Then, combined with the wage based on the rule of thumb, where it follows the previous wage, we have this equation.

$W_t \equiv [\theta_w W_{t-1}^{1-\varepsilon_w} + (1 - \theta_w) \bar{W}_{H,t}^{1-\varepsilon_w}]^{\frac{1}{1-\varepsilon_w}}$, log linearize it, we get this result as follows.

$$\tilde{w}_t = \theta_w \tilde{w}_{t-1} + (1 - \theta_w) \tilde{\tilde{w}}_t \quad (4A.63)$$

$$\tilde{w}_t - \tilde{w}_{t-1} = \theta_w \tilde{w}_{t-1} - \tilde{w}_{t-1} + (1 - \theta_w) \tilde{\tilde{w}}_t$$

$$\tilde{w}_t - \tilde{w}_{t-1} = (1 - \theta_w)(\tilde{\tilde{w}}_t - \tilde{w}_{t-1}) \quad (4A.64)$$

and hence $E_t(\tilde{w}_{t+1} - \tilde{w}_t) = (1 - \theta_w) E_t(\tilde{\tilde{w}}_{t+1} - \tilde{w}_t)$

Given that, $E_t(\tilde{\tilde{w}}_{t+1} - \tilde{w}_t) = \frac{1}{1-\theta_w} E_t(\tilde{w}_{t+1} - \tilde{w}_t)$, plug this into (4A.62) to get

$\tilde{w}_t - \tilde{w}_{t-1} = (1 - \beta\theta_w)(\tilde{m}r s_t + \tilde{p}_t - \tilde{w}_t) + \tilde{\pi}_t^w + \beta\theta_w \frac{1}{1-\theta_w} E_t(\tilde{w}_{t+1} - \tilde{w}_t)$, and plug this into (4A.64)

$$\tilde{w}_t - \tilde{w}_{t-1} = (1 - \theta_w) \left[(1 - \beta\theta_w)(\tilde{m}r s_t + \tilde{p}_t - \tilde{w}_t) + \tilde{\pi}_t^w + \beta\theta_w \frac{1}{1-\theta_w} E_t(\tilde{w}_{t+1} - \tilde{w}_t) \right]$$

$$\tilde{\pi}_t^w = (1 - \theta_w) \left[(1 - \beta\theta_w) \tilde{m}c_t^w + \tilde{\pi}_t^w + \beta\theta_w \frac{1}{1-\theta_w} E_t \tilde{\pi}_{t+1}^w \right]$$

$$\pi_t^w = \beta E_t \pi_{t+1}^w + \lambda (\tilde{m}r s_t - (\tilde{w}_t - \tilde{p}_t)) \quad (4A.65)$$

where $\lambda = \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w}$ and $\tilde{m}r s_t$ is equal to marginal rate of substitution between labour and leisure time $= -\frac{U_N}{U_C}$, or

$$\tilde{m}r s_t = \varphi \tilde{n}_t + \sigma \tilde{c}_t \quad (4A.66)$$

Demand for labour

The demand for labour is the summation of demand for labour in food and non-food sector. Log linearize around its steady state will yield

$$\tilde{n}_t = \frac{Y_{hM}}{Y} \left(\tilde{y}_{hM,t} + (1 - \phi)(\tilde{p}_{o,t} - \tilde{w}_t) \right) + \frac{Y_{hF}}{Y} \left(\tilde{y}_{hF,t} + (1 - \phi_L)(\tilde{p}_{L,t} - \tilde{w}_t) \right) \quad (4A.67)$$

Marginal cost

$$MC_{hM,t} = \frac{1}{A_t} \frac{P_t}{P_{hM,t}} \left(\frac{P_{o,t}}{P_t} \right)^{1-\phi} \left(\frac{W_t}{P_t} \right)^\phi \left(\frac{1}{1-\phi} \right) \left(\frac{1-\phi}{\phi} \right)^\phi$$

Log linearization using subtraction log variable with its log steady state, we get the real marginal cost of the non-food firms,

$$\tilde{mc}_{hM,t} = (1 - \phi)\tilde{p}_{o,t} + \phi\tilde{w}_t - \tilde{p}_{hM,t} \quad (4A.68)$$

Analogously for the food firms,

$$\tilde{mc}_{hF,t} = (1 - \phi)\tilde{p}_{L,t} + \phi\tilde{w}_t - \tilde{p}_{hF,t} \quad (4A.69)$$

Domestic non-food and food inflation

$$\bar{P}_{hM,t} \sum_{k=0}^{\infty} (\beta\theta)^k \Gamma_{t+k} = \frac{\varepsilon}{(\varepsilon-1)} P_{hM,t-1} \sum_{k=0}^{\infty} (\beta\theta)^k \Gamma_{t+k} \Pi_{t-1,t+k}^M MC_{t+k}$$

$$\text{Where } \Gamma_{t+k} = E_t \left\{ C_{t+k}^{-\sigma} \frac{Y_{t+k}^d}{P_{t+k}} \right\}$$

The LHS of this equation can be rewritten:

$$\begin{aligned} &= \sum_{k=0}^{\infty} (\beta\theta)^k P_{hM} \Gamma E_t (1 + \tilde{I}_{t+k} + \tilde{p}_{hM,t}) \\ &= \Gamma P_{hM} \sum_{k=0}^{\infty} (\beta\theta)^k E_t (1 + \tilde{I}_{t+k} + \tilde{p}_{hM,t}) \quad \text{since the index of } \tilde{p}_{hM,t} \text{ is } t, \text{ not } k, \text{ we treat it as a constant} \\ &= \frac{\Gamma P_{hM}}{1-\beta\theta} (1 + \tilde{p}_{hM,t}) + \Gamma P_{hM} \sum_{k=0}^{\infty} (\beta\theta)^k E_t (\tilde{I}_{t+k}) \end{aligned}$$

We can write the RHS:

$$\begin{aligned} &= \frac{\varepsilon}{(\varepsilon-1)} \sum_{k=0}^{\infty} (\beta\theta)^k E_t (P_{hM,t-1} \Gamma_{t+k} \Pi_{t-1,t+k}^M MC_{t+k}) \\ &= \frac{\varepsilon}{(\varepsilon-1)} P_{hM} \Gamma \Pi MC \sum_{k=0}^{\infty} (\beta\theta)^k E_t (e^{\tilde{p}_{hM,t-1} + \tilde{I}_{t+k} + \tilde{\Pi}_{t-1,t+k}^M + \tilde{mc}_{t+k}}) \\ &= \frac{\varepsilon}{(\varepsilon-1)} P_{hM} \Gamma \Pi MC \sum_{k=0}^{\infty} (\beta\theta)^k E_t (1 + \tilde{p}_{hM,t-1} + \tilde{I}_{t+k} + \tilde{\Pi}_{t-1,t+k}^M + \tilde{mc}_{t+k}) \\ &= \frac{\varepsilon}{(\varepsilon-1)} P_{hM} \Gamma \Pi MC \frac{1}{1-\beta\theta} (1 + \tilde{p}_{hM,t-1}) + \frac{\varepsilon}{(\varepsilon-1)} P_{hM} \Gamma \Pi MC \sum_{k=0}^{\infty} (\beta\theta)^k E_t (\tilde{I}_{t+k} + \tilde{\Pi}_{t-1,t+k}^M + \tilde{mc}_{t+k}) \end{aligned}$$

Note that in steady state becomes

$$P_{hM} = \frac{\varepsilon}{(\varepsilon-1)} \frac{P_{hM} \sum_{k=0}^{\infty} (\beta\theta)^k \Gamma \Pi MC}{\sum_{k=0}^{\infty} (\beta\theta)^k \Gamma}$$

$$\frac{\varepsilon}{(\varepsilon-1)} = \frac{1}{\Pi MC}$$

So that RHS becomes,

$$= P_{hM} \Gamma \frac{1}{1-\beta\theta} (1 + \tilde{p}_{hM,t-1}) + P_{hM} \Gamma \sum_{k=0}^{\infty} (\beta\theta)^k E_t(\tilde{\Gamma}_{t+k} + \tilde{\Pi}_{t-1,t+k}^M + \tilde{m}\tilde{c}_{t+k})$$

Equalize LHS and RHS, we get

$$\begin{aligned} \frac{\Gamma P_{hM}}{1-\beta\theta} (1 + \tilde{p}_{hM,t}) + \Gamma P_{hM} \sum_{k=0}^{\infty} (\beta\theta)^k E_t(\tilde{\Gamma}_{t+k}) &= P_{hM} \Gamma \frac{1}{1-\beta\theta} (1 + \tilde{p}_{hM,t-1}) + \\ P_{hM} \Gamma \sum_{k=0}^{\infty} (\beta\theta)^k E_t(\tilde{\Gamma}_{t+k} + \tilde{\Pi}_{t-1,t+k}^M + \tilde{m}\tilde{c}_{t+k}) & \\ \tilde{p}_{hM,t} - \tilde{p}_{hM,t-1} &= (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t(\tilde{p}_{hM,t+k} - \tilde{p}_{hM,t-1} + \tilde{m}\tilde{c}_{t+k}) \end{aligned} \quad (4A.70)$$

Above equation can be rewritten as follows:

$$\tilde{p}_{hM,t} - \tilde{p}_{hM,t-1} = (1 - \beta\theta) \tilde{m}\tilde{c}_t + \tilde{\pi}_{hM,t} + (1 - \beta\theta) \beta\theta \sum_{k=0}^{\infty} (\beta\theta)^k E_t(\tilde{p}_{hM,t+k+1} - \tilde{p}_{hM,t} + \tilde{m}\tilde{c}_{t+k+1}) \quad (4A.71)$$

Rewrite the equation (4A.71) to $\tilde{p}_{hM,t+1} - \tilde{p}_{hM,t}$ and take the expectation we get

$$E_t(\tilde{p}_{hM,t+1} - \tilde{p}_{hM,t}) = (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t(\tilde{p}_{hM,t+k+1} - \tilde{p}_{hM,t} + \tilde{m}\tilde{c}_{t+k+1}) \quad (4A.72)$$

Plug equation (19) into equation (18), we get

$$\begin{aligned} \tilde{p}_{hM,t} - \tilde{p}_{hM,t-1} &= (1 - \beta\theta) \tilde{m}\tilde{c}_t + \tilde{\pi}_{hM,t} + \beta\theta E_t(\tilde{p}_{hM,t+1} - \tilde{p}_{hM,t}) \\ \tilde{p}_{hM,t} - \tilde{p}_{hM,t-1} &= \pi_{hM,t} + \beta\theta E_t(\tilde{p}_{hM,t+1} - \tilde{p}_{hM,t}) + (1 - \beta\theta) \tilde{m}\tilde{c}_t \end{aligned} \quad (4A.73)$$

As we know the combination between domestic price that is set according to optimization problem and that follows the previous price is reflected on the composite below:

$$P_{hM,t} \equiv [\theta P_{hM,t-1}^{1-\varepsilon} + (1 - \theta) \bar{P}_{hM,t}^{1-\varepsilon}]^{\frac{1}{1-\varepsilon}}$$

Using First Order Taylor approximation to find its log linear around steady state, we get

$$\tilde{p}_{hM,t} \approx \theta \tilde{p}_{hM,t-1} + (1 - \theta) \tilde{p}_{hM,t} \quad (4A.74)$$

Rewrite it, we get $\tilde{p}_{hM,t} - \tilde{p}_{hM,t-1} = \theta \tilde{p}_{hM,t-1} - \tilde{p}_{hM,t-1} + \tilde{p}_{hM,t} - \theta \tilde{p}_{hM,t}$

$$\pi_{hM,t} = (1 - \theta)(\tilde{p}_{hM,t} - \tilde{p}_{hM,t-1}) \quad (4A.75)$$

It follows $E_t(\pi_{hM,t+1}) = (1 - \theta) E_t(\tilde{p}_{hM,t+1} - \tilde{p}_{hM,t})$

$$E_t(\tilde{p}_{hM,t+1} - \tilde{p}_{hM,t}) = \frac{1}{(1-\theta)} E_t(\pi_{hM,t+1})$$

Given the above equation, equation (4A.72) is rewritten as follow

$$\tilde{p}_{hM,t} - \tilde{p}_{hM,t-1} = \pi_{hM,t} + \beta\theta \frac{1}{(1-\theta)} E_t(\pi_{hM,t+1}) + (1-\beta\theta)\tilde{m}\tilde{c}_t \quad (4A.76)$$

Plugging equation (4A.76) into (4A.75)

$$\begin{aligned} \pi_{hM,t} &= (1-\theta) \left[\pi_{hM,t} + \beta\theta \frac{1}{(1-\theta)} E_t(\pi_{hM,t+1}) + (1-\beta\theta)\tilde{m}\tilde{c}_t \right] \\ \pi_{hM,t} &= (1-\theta)\pi_{hM,t} + \beta\theta E_t(\pi_{hM,t+1}) + (1-\theta)(1-\beta\theta)\tilde{m}\tilde{c}_t \\ \pi_{hM,t} &= \beta E_t(\pi_{hM,t+1}) + \lambda\tilde{m}\tilde{c}_t \end{aligned} \quad (4A.77)$$

$$\text{where } \lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$$

The result is the standard New Keynesian Phillips Curve where inflation depends on expected inflation and the marginal cost. Analogously, the food producers will also set their price given their monopoly power. The inflation in the domestic food sector will be determined by the equations below.

$$\pi_{hF,t} = \beta E_t(\pi_{hF,t+1}) + \lambda_{hF}\tilde{m}\tilde{c}_{hF,t} \quad (4A.78)$$

$$\text{Where } \lambda_{hF} = \frac{(1-\theta_{hF})(1-\beta\theta_{hF})}{\theta_{hF}}.$$

Terms of Trade

$$\tilde{s}_t = \tilde{p}_{f,t} - \tilde{p}_{h,t} \quad (4A.79)$$

Substitute into price equation yields

$$\tilde{p}_t = (1-\alpha)\tilde{p}_{h,t} + \alpha(\tilde{s}_t + \tilde{p}_{h,t})$$

$$\tilde{p}_t = \tilde{p}_{h,t} + \alpha\tilde{s}_t, \text{ hence}$$

$$\pi_t = \pi_{h,t} + \alpha\Delta\tilde{s}_t \quad (4A.80)$$

Law of One Price

$$P_{i,t} = P_{i,t}^i \mathcal{E}_{i,t}$$

Log linearization around the steady state and integrate for all foreign country yields

$$\tilde{p}_{f,t} = \int_0^1 (\tilde{p}_{i,t}^* + \tilde{e}_{i,t}) di$$

$$\tilde{p}_{f,t} = \tilde{p}_t^* + \tilde{e}_t$$

Where e_t is the effective nominal exchange rate. Thus, the term of trade can be rewritten as follows:

$$\tilde{s}_t = \tilde{p}_t^* + \tilde{e}_t - \tilde{p}_{h,t} \quad (4A.81)$$

Real exchange rate

$$\Omega_{i,t} = \frac{\varepsilon_{i,t} P_t^i}{P_t}$$

Its log linearization around the steady state is

$$\tilde{q}_{i,t} = \tilde{e}_{i,t} + \tilde{p}_{i,t}^* - \tilde{p}_t$$

Or the effective real exchange rate will be as follows:

$$\begin{aligned} \tilde{q}_t &= \int_0^1 \tilde{q}_{i,t} di = \int_0^1 (\tilde{e}_{i,t} + \tilde{p}_{i,t}^* - \tilde{p}_t) di \\ \tilde{q}_t &= \tilde{e}_t + \tilde{p}_t^* - \tilde{p}_t \end{aligned} \quad (4A.82)$$

To link between terms of trade and the real exchange rate, we combine equation (4A.81) and (4A.82) to get

$$\tilde{q}_t = \tilde{s}_t + \tilde{p}_{h,t} - \tilde{p}_t \quad (4A.83)$$

From equation (4A.80) we get $\tilde{p}_{h,t} - \tilde{p}_t = \alpha \tilde{s}_t$, plug into (4A.82), we get

$$\tilde{q}_t = \tilde{s}_t + \alpha \tilde{s}_t = (1 + \alpha) \tilde{s}_t \quad (4A.84)$$

The Link between domestic and foreign consumption

$$C_t = C_t^i \Omega_{i,t}^{\frac{1}{\sigma}}$$

Log linearize this equation and integrate it over i we get,

$$\begin{aligned} \tilde{c}_t &= \tilde{c}_t^* + \frac{1}{\sigma} \tilde{q}_t \\ \tilde{c}_t &= \tilde{c}_t^* + \frac{(1+\alpha)}{\sigma} \tilde{s}_t \end{aligned} \quad (4A.85)$$

Where \tilde{c}_t^* is the world consumption.

Rest of the World

We assume each foreign country in the rest of the world has the same composite price as in our small open economy as follows:

$$\tilde{p}_{i,t}^* \approx (1 - \alpha_1 - \alpha_2) \tilde{p}_{fM,i,t}^* + \alpha_1 \tilde{p}_{fO,i,t}^* + \alpha_2 \tilde{p}_{fF,i,t}^* \quad (4A.86)$$

Price composite of the world is as follows:

$$\tilde{p}_t^* = \int_0^1 \left((1 - \alpha_1 - \alpha_2) \tilde{p}_{fM,i,t}^* + \alpha_1 \tilde{p}_{fO,i,t}^* + \alpha_2 \tilde{p}_{fF,i,t}^* \right) di$$

$$\tilde{p}_t^* \approx (1 - \alpha_1 - \alpha_2)\tilde{p}_{fM,t}^* + \alpha_1\tilde{p}_{O,t}^* + \alpha_2\tilde{p}_{fF,t}^* \quad (4A.87)$$

Uncovered Interest Parity

Assuming complete integrate international financial market, we can have these two equations.

$$\frac{R_t^i}{\varepsilon_{i,t}} E_t \{ Q_{t,t+1} \varepsilon_{i,t+1} \} = R_t E_t \{ Q_{t,t+1} \} \quad \text{and} \quad E_t \left\{ Q_{t,t+1} \left[R_t - R_t^i \frac{\varepsilon_{i,t+1}}{\varepsilon_{i,t}} \right] \right\} = 0$$

Equate these two equation and log linearize it, it yields the interest rate differential:

$$\tilde{r}_t - \tilde{r}_t^* = E_t \{ \Delta \tilde{e}_{t+1} \} \quad (4A.88)$$

Given $\tilde{s}_t = \tilde{p}_t^* + \tilde{e}_t - \tilde{p}_{h,t}$ equation (4A.88) becomes

$$\tilde{s}_t = \tilde{r}_t^* - E_t \pi_{t+1}^* - (\tilde{r}_t - E_t \tilde{\pi}_{t+1}) + E_t \tilde{s}_{t+1} \quad (4A.89)$$

Solving this equation forward will yield,

$$\tilde{s}_t = E_t \{ \sum_{k=0}^{\infty} [\tilde{r}_{t+k}^* - E_t \pi_{t+k+1}^* - (\tilde{r}_{t+k} - E_t \tilde{\pi}_{t+k+1})] \} \quad (4A.90)$$

Demand for domestic goods

$$Y_{hM,t} = S_t^{\alpha\eta} P_{hM,t}^{-\kappa} P_{h,t}^{\kappa} C_t (1 - \alpha)(1 - \alpha_3) +$$

$$S_t^{\alpha\eta} P_{hM,t}^{-\kappa} P_{h,t}^{\kappa} \alpha(1 - \alpha_3) C_t \int_0^1 (S_{i,t} S_t^i)^{\gamma-\eta} \Omega_{i,t}^{\eta-\frac{1}{\sigma}} di$$

Using a first order Taylor approximation, we find,

$$Y_{hM}(1 + \tilde{y}_{hM,t}) = S^{\alpha\eta} P_{hM}^{-\kappa} P_h^{\kappa} C (1 - \alpha)(1 - \alpha_3) (1 + \alpha\eta\tilde{s}_t - \kappa\tilde{p}_{hM,t} + \kappa\tilde{p}_{h,t} + \tilde{c}_t) + S^{\alpha\eta} P_{hM}^{-\kappa} P_h^{\kappa} C \alpha(1 - \alpha_3) \left[1 + \alpha\eta\tilde{s}_t - \kappa\tilde{p}_{hM,t} + \kappa\tilde{p}_{h,t} + \tilde{c}_t + (\gamma - \eta) \int_0^1 \tilde{s}_{i,t} di + (\gamma - \eta) \int_0^1 \tilde{s}_t^i di + \left(\eta - \frac{1}{\sigma} \right) \int_0^1 \tilde{q}_{i,t} di \right]$$

This equation can be rewritten:

$$1 + \tilde{y}_{hM,t} = 1 + \alpha\eta\tilde{s}_t - \kappa\tilde{p}_{hM,t} + \kappa\tilde{p}_{h,t} + \tilde{c}_t + \alpha(\gamma - \eta)\tilde{s}_t + \alpha\left(\eta - \frac{1}{\sigma}\right)\tilde{q}_t$$

$$\tilde{y}_{hM,t} = \alpha\eta\tilde{s}_t - \kappa\tilde{p}_{hM,t} + \kappa\tilde{p}_{h,t} + \tilde{c}_t + \alpha(\gamma - \eta)\tilde{s}_t + (1 - \alpha)\left(\eta - \frac{1}{\sigma}\right)\tilde{s}_t$$

$$\tilde{y}_{hM,t} = \kappa(\tilde{p}_{h,t} - \tilde{p}_{hM,t}) + \tilde{c}_t + \left[\alpha\gamma + (1 - \alpha)\left(\eta - \frac{1}{\sigma}\right) \right] \tilde{s}_t \quad (4A.91)$$

Given this equation, if $\tilde{p}_{hM,t}$ increases, the household will consume less non-food so that its demand will decrease. In equilibrium, the firms will also produce less. Analogously we can derived the equilibrium in food market as follows:

$$\tilde{y}_{hF,t} = \kappa(\tilde{p}_{h,t} - \tilde{p}_{fF,t}) + \tilde{c}_t + \left[\alpha\gamma + (1 - \alpha)\left(\eta - \frac{1}{\sigma}\right) \right] \tilde{s}_t \quad (4A.92)$$

The total output is, $Y_t = Y_{hM,t} + Y_{hF,t}$. Log linearize around its steady state,

$$Y(1 + \tilde{y}_t) = Y_{hM}(1 + \tilde{y}_{hM,t}) + Y_{hF}(1 + \tilde{y}_{hF,t})$$

$$(1 + \tilde{y}_t) = \frac{Y_{hM}}{Y}(1 + \tilde{y}_{hM,t}) + \frac{Y_{hF}}{Y}(1 + \tilde{y}_{hF,t})$$

$$\tilde{y}_t = \frac{Y_{hM}}{Y}\tilde{y}_{hM,t} + \frac{Y_{hF}}{Y}\tilde{y}_{hF,t}$$

$$\tilde{y}_t = (1 - \alpha_3)\tilde{y}_{hM,t} + \alpha_3\tilde{y}_{hF,t} \tag{4A.93}$$

Appendix 4.3. Dynare Code For Estimation

```
// A small open economy model with oil and food price

close all;

var
y_hm y_hf y c a r dr de e s pi_w mrs n mc_hm mc_hf w p_o p_l p_h p_f p_hm
p_hf pi_hm pi_hf pi pi_f pi_fm pi_o pi_ff pi_h pi_l pi_c pi_nc pi_fd
r_star pi_star pi_o_star pi_ff_star pi_fm_star dlog_y dlog_c dlog_y_hm
dlog_y_hf;
varexo
e_o e_ff e_fm e_rstar e_l e_r e_a e_hf e_hm e_ho;

parameters
kappa alpha gamma eta sigma rho psi1 psi2 psi3 beta phic theta_w theta_hm
theta_hf phi phi_l alphas1 alpha2 alpha3 rho_o rho_ff rho_fm rho_rstar
rho_l rho_a;

% Predetermined parameters
beta = 0.99;           //Discount factor of household utility function
alpha = 0.27;          //Ratio of foreign good consumption in household
bundle of consumption or degree of openness
alpha2 = 0.05;         //Ratio of food consumption in household bundle of
foreign good consumption
alpha3 = 0.49;         //Ratio of food consumption in household bundle of
domestic good consumption
rho_o = 0.3;           //Coefficient in world oil price shock
rho_fm = 0.5;          //Coefficient in world other goods price shock
rho_ff = 0.24;         //Coefficient in world food price shock
rho_rstar = 0.6;       //Coefficient in world interest rate shock
rho_a = 0.8;           //Coefficient in technological shock
phic = 3;              //The elasticity of substitution of labour time (1-
leisure time) in household utility function

% Estimated Parameters
alphas1 = 0.3;         //Ratio of oil consumption in household bundle of
foreign good consumption
phi = 0.5;             //Share of labour in manufacturing firm production
function
phi_l = 0.5;           //Share of labour in food producer production
function
sigma = 2.6027;        //CRRA
eta = 0.5;             //The elasticity of substitution between domestic and
foreign good consumption in bundle of consumption
kappa = 0.5;           //The elasticity of substitution between domestic
manufacturing and food good consumption in bundle of domestic consumption
gamma = 1;             //The elasticity of substitution between foreign good
consumption from country i in bundle of domestic consumption
theta_hm = 0.5;        //Rigidity1: probability or fraction of
manufacturing firms that set their price according to the previous price
theta_hf = 0.5;        //Rigidity2: probability or fraction of food producers
that set their price according to the previous price
theta_w = 0.5;         //Rigidity3: probability or fraction of household
that set their wage according to the previous wage
rho_l = 0.5;           //Coefficient in land price shock
rho = 0.5;             //Coefficient of interest rate smoothing in policy
rule
```

```

psi1 = 1.5;           //Coefficient of inflation in policy rule
psi2 = 0.25;          //Coefficient of output in policy rule
psi3 = 0.25;          //Coefficient of nominal exchange rate in policy rule

model(linear);

# lambda_hm = (1-theta_hm)*(1-beta*theta_hm)/theta_hm;
# lambda_hf = (1-theta_hf)*(1-beta*theta_hf)/theta_hf;
# lambda_w = (1-theta_w)*(1-beta*theta_w)/theta_w;

% Aggregate demand

y_hm = kappa * (p_h - p_hm) + c + (alpha * gamma + (eta - 1/sigma) * (1 -
alpha)) * s;
y_hf = kappa * (p_h - p_hf) + c + (alpha * gamma + (eta - 1/sigma) * (1 -
alpha)) * s;

y = (1-alpha3) * y_hm + alpha3 * y_hf;
c = c(+1) + a(+1) - (1/sigma) * (r - pi(+1));

% MP based on Lubik Schorfeide
r = rho * r(-1) + (1 - rho) * (psi1 * pi + psi2 * y + psi3 * de) + e_r;
dr = r - r(-1);

% Aggregate supply NKPC

pi_hm = beta * pi_hm(+1) + lambda_hm * mc_hm;
mc_hm = (1 - phi) * p_o + phi * w - p_hm;

pi_hf = beta * pi_hf(+1) + lambda_hf * mc_hf;
mc_hf = (1 - phi_l) * p_l + phi_l * w - p_hf;

pi_w = beta * pi_w(+1) + lambda_w * (mrs - w);
mrs = phic * n + sigma * c;
n = (1-alpha3) * (y_hm + (1 - phi) * (p_o - w)) + alpha3 * (y_hf + (1 -
phi_l) * (p_l - w));

% International relationship
r - r_star = de(+1);
s - s(-1) = pi_f - pi_h;
e = de + e(-1);

% Prices
pi = (1 - alpha) * pi_h + alpha * pi_f;
pi_h = (1 - alpha3) * pi_hm + alpha3 * pi_hf;
pi_f = (1 - alpha1 - alpha2) * pi_fm + alpha1 * pi_o + alpha2 * pi_ff;
pi_o = pi_o_star + de + e_ho;
p_o = p_o(-1) + pi_o;
p_l = p_l(-1) + pi_l;
w - w(-1) = pi_w - pi;
p_h - p_h(-1) = pi_h - pi;
p_f - p_f(-1) = pi_f - pi;
p_hm - p_hm(-1) = pi_hm - pi;
p_hf - p_hf(-1) = pi_hf - pi;
pi_ff = pi_ff_star + de + e_hf;
pi_fm = pi_fm_star + de + e_hm;
pi_star = (1 - alpha1 - alpha2) * pi_fm_star + alpha1 * pi_o_star +

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```

alpha2 * pi_ff_star;
pi_c = (1 - alpha) * (1 - alpha3) * pi_hm + alpha * (1 - alpha1 - alpha2)
* pi_fm;
pi_nc = (1 - alpha) * alpha3 * pi_hf + alpha * alpha1 * pi_o + alpha *
alpha2 * pi_ff;
pi_fd = (1 - alpha) * alpha3 * pi_hf + alpha * alpha2 * pi_ff;

% Measurement equation

dlog_y = y - y(-1) + a;
dlog_c = c - c(-1) + a;
dlog_y_hm = y_hm - y_hm(-1) + a;
dlog_y_hf = y_hf - y_hf(-1) + a;

% Shocks

pi_o_star = rho_o * pi_o_star(-1) + e_o;
pi_ff_star = rho_ff * pi_ff_star(-1) + e_ff;
pi_fm_star = rho_fm * pi_fm_star(-1) + e_fm;
r_star = rho_rstar * r_star(-1) + e_rstar;
pi_l = rho_l * pi_l(-1) + e_l;
a = rho_a * a(-1) + e_a;

end;

initval;
y_hm = 0;
y_hf = 0;
y = 0;
c = 0;
a = 0;
r = 0;
dr = 0;
e = 0;
de = 0;
s = 0;
pi_w = 0;
mrs = 0;
n = 0;
mc_hm = 0;
mc_hf = 0;
w = 0;
p_o = 0;
p_l = 0;
p_h = 0;
p_hm = 0;
p_hf = 0;
pi_hm = 0;
pi_hf = 0;
pi = 0;
pi_f = 0;
pi_fm = 0;
pi_o = 0;
pi_ff = 0;
pi_h = 0;
pi_l = 0;
pi_c = 0;
pi_nc = 0;

```

```

pi_fd = 0;
r_star = 0;
pi_star = 0;
pi_o_star = 0;
pi_ff_star = 0;
pi_fm_star = 0;
dlog_y = 0;
dlog_c = 0;
dlog_y_hm = 0;
dlog_y_hf = 0;

end;

shocks;
var e_o; stderr 0.14;
var e_ff; stderr 0.069;
var e_fm; stderr 0.076;
var e_rstar; stderr 0.44;
var e_l; stderr 0.01;
var e_r; stderr 0.01;
var e_a; stderr 0.01;
end;

steady;
check;

estimated_params;

alpha1, beta_pdf, 0.33, 0.2;
phi, beta_pdf, 0.5, 0.2;
phi_l, beta_pdf, 0.5, 0.2;
sigma, gamma_pdf, 1.55, 0.198;
eta, beta_pdf, 0.5, 0.2;
kappa, beta_pdf, 0.5, 0.2;
gamma, gamma_pdf, 1, 0.2;
theta_hm, beta_pdf, 0.5, 0.2;
theta_w, beta_pdf, 0.5, 0.1;
theta_hf, beta_pdf, 0.5, 0.2;
rho_l, beta_pdf, 0.5, 0.2;
rho, beta_pdf, 0.5, 0.2;
psi1, gamma_pdf, 1.5, 0.13;
psi2, gamma_pdf, 0.25, 0.13;
psi3, gamma_pdf, 0.25, 0.13;
stderr e_l, inv_gamma_pdf, 0.01, inf;
stderr e_r, inv_gamma_pdf, 0.01, inf;
stderr e_a, inv_gamma_pdf, 0.01, inf;
stderr e_hf, inv_gamma_pdf, 0.01, inf;
stderr e_hm, inv_gamma_pdf, 0.01, inf;
stderr e_ho, inv_gamma_pdf, 0.01, inf;

end;

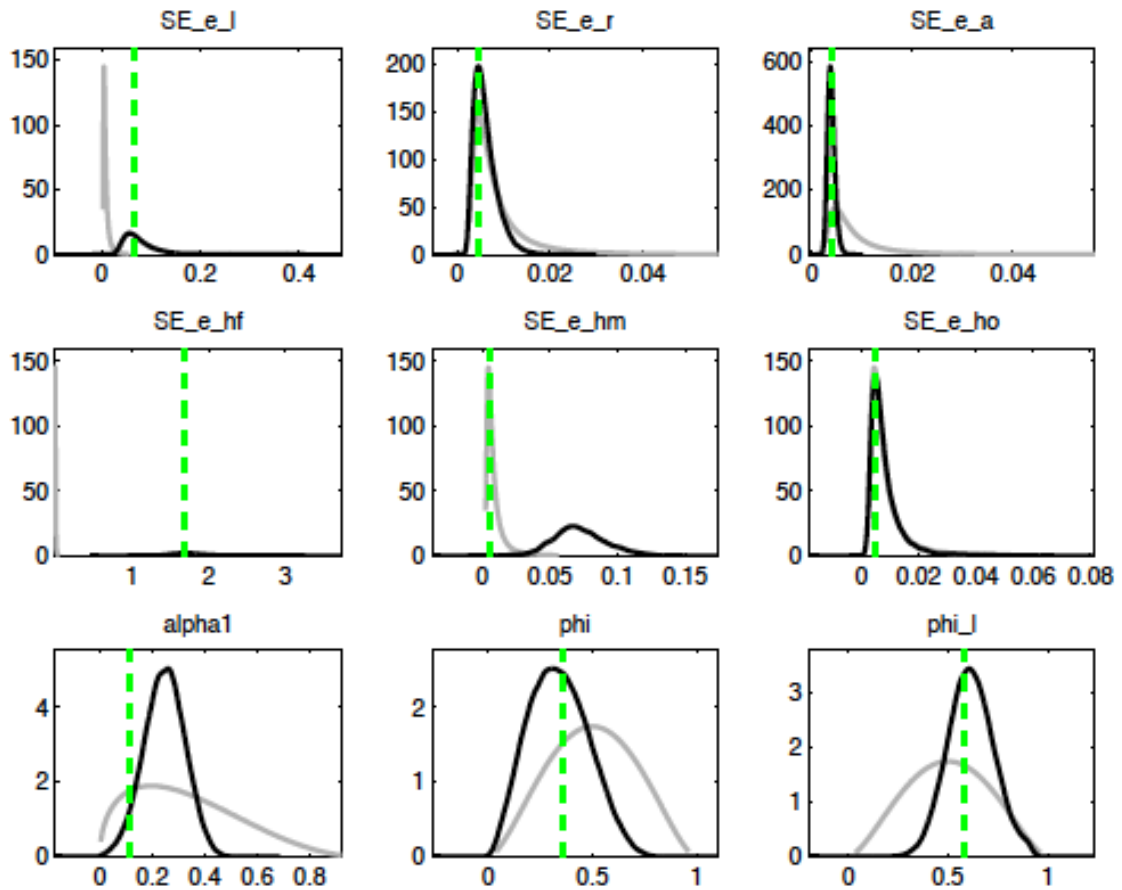
varobs dlog_y dlog_c pi pi_fd pi_o de;
estimation(order = 1, datafile=DataIndo, lik_init=2, mode_compute = 4,
first_obs=1, mh_replic=500000, mh_nblocks=2, mh_drop=0.5,
mh_jscale=0.46);
shock_decomposition dlog_y pi;

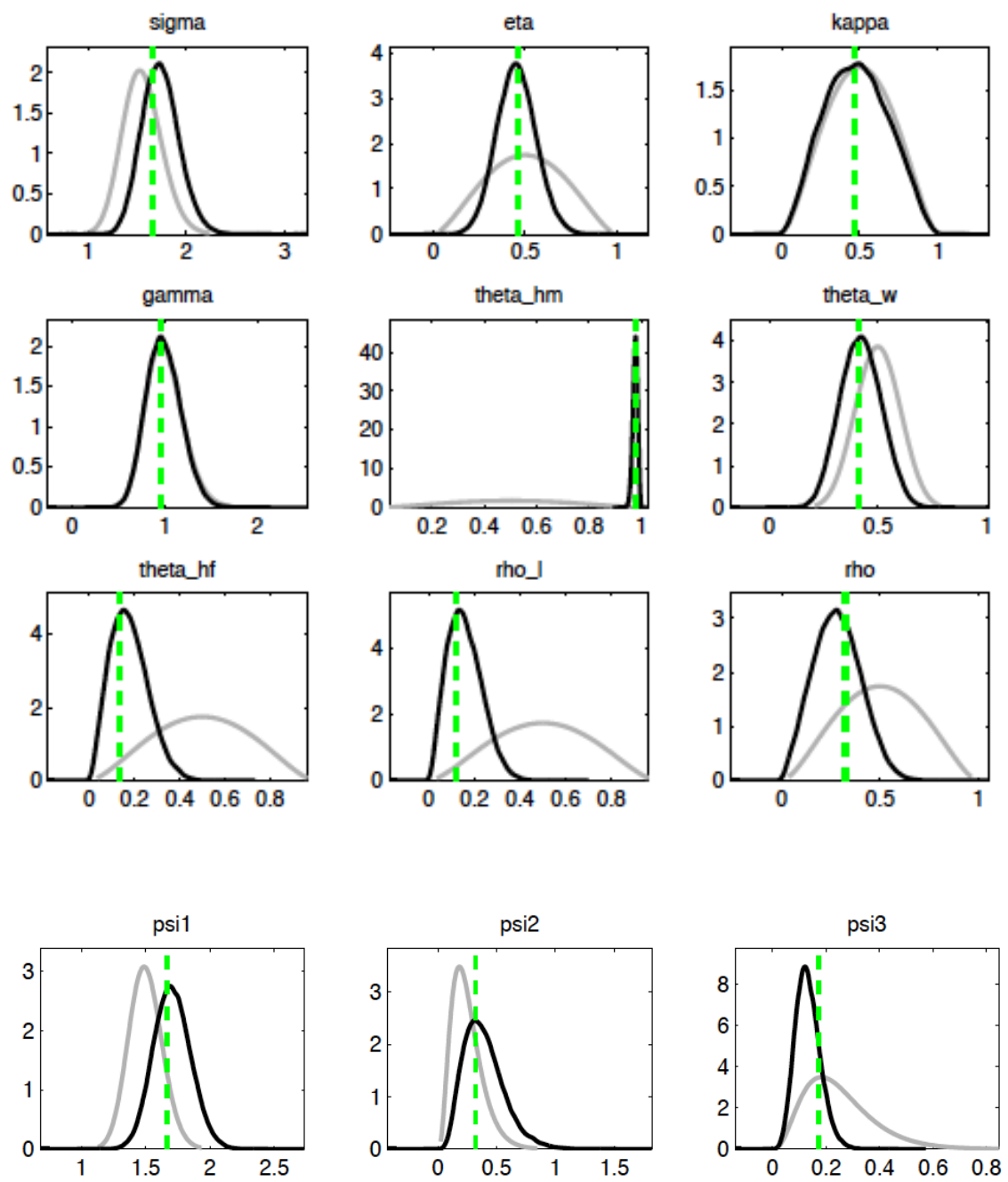
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Appendix 4.4. Estimation Results: The Distribution of Priors and Posteriors of the Estimated Parameters

Indonesia

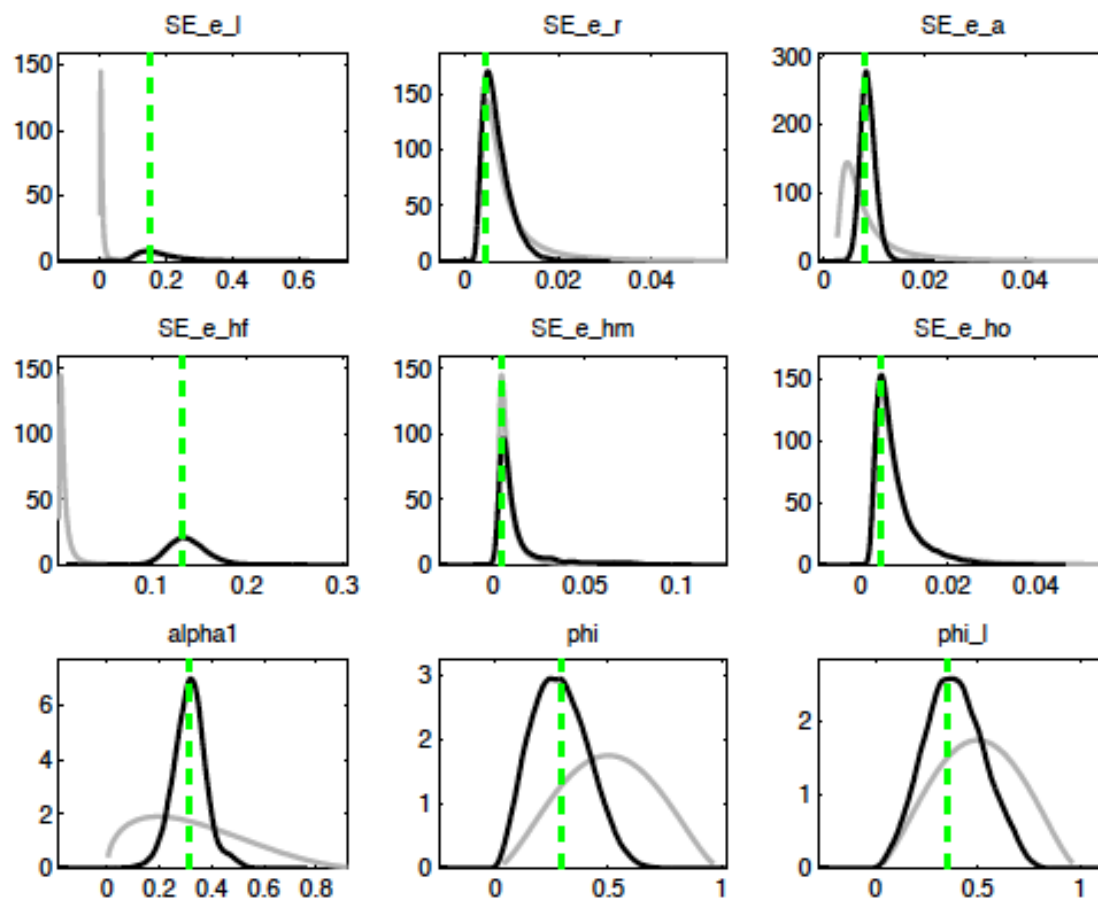
(light line curve is prior distribution, bold line curve is posterior distribution)

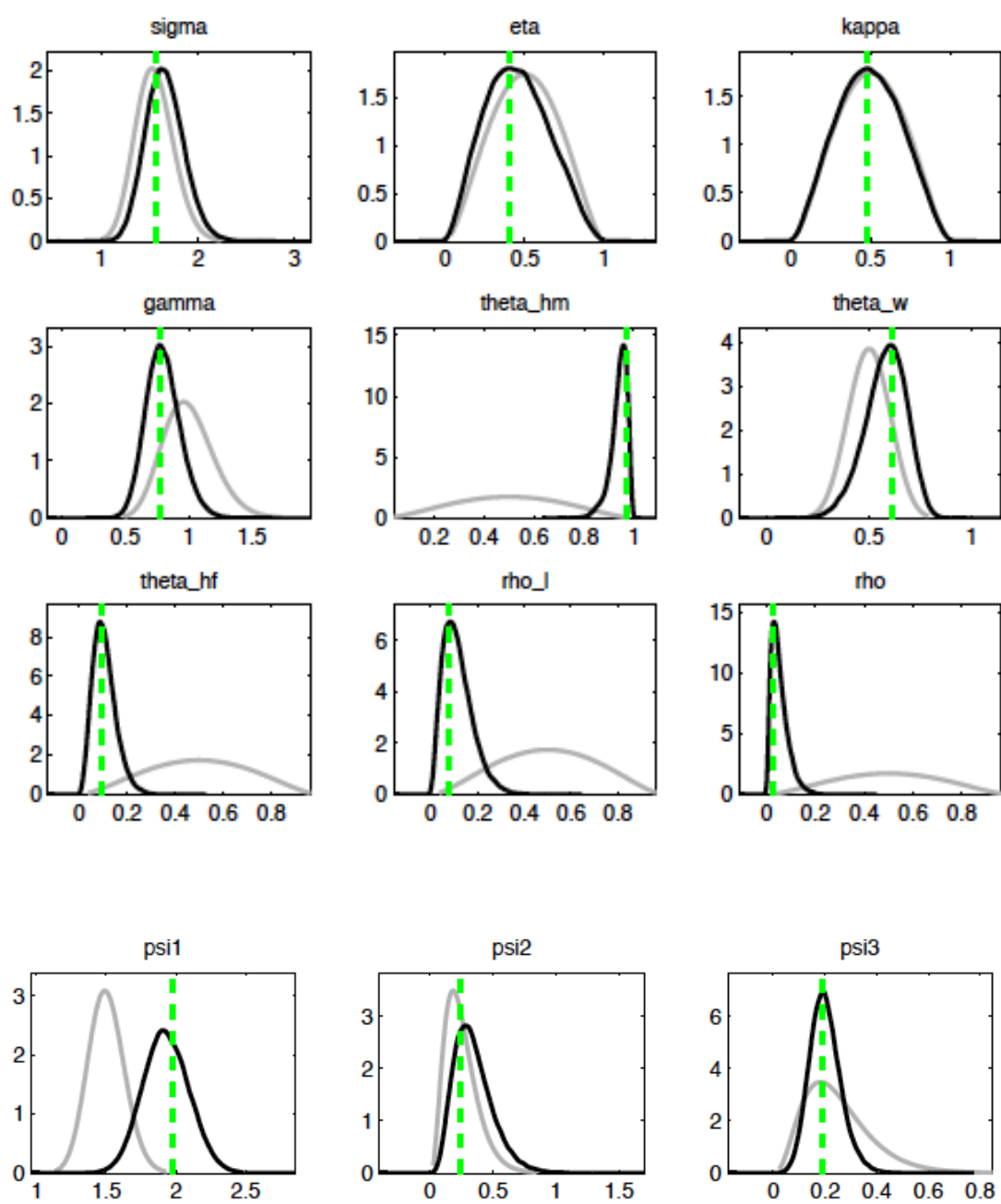




Korea

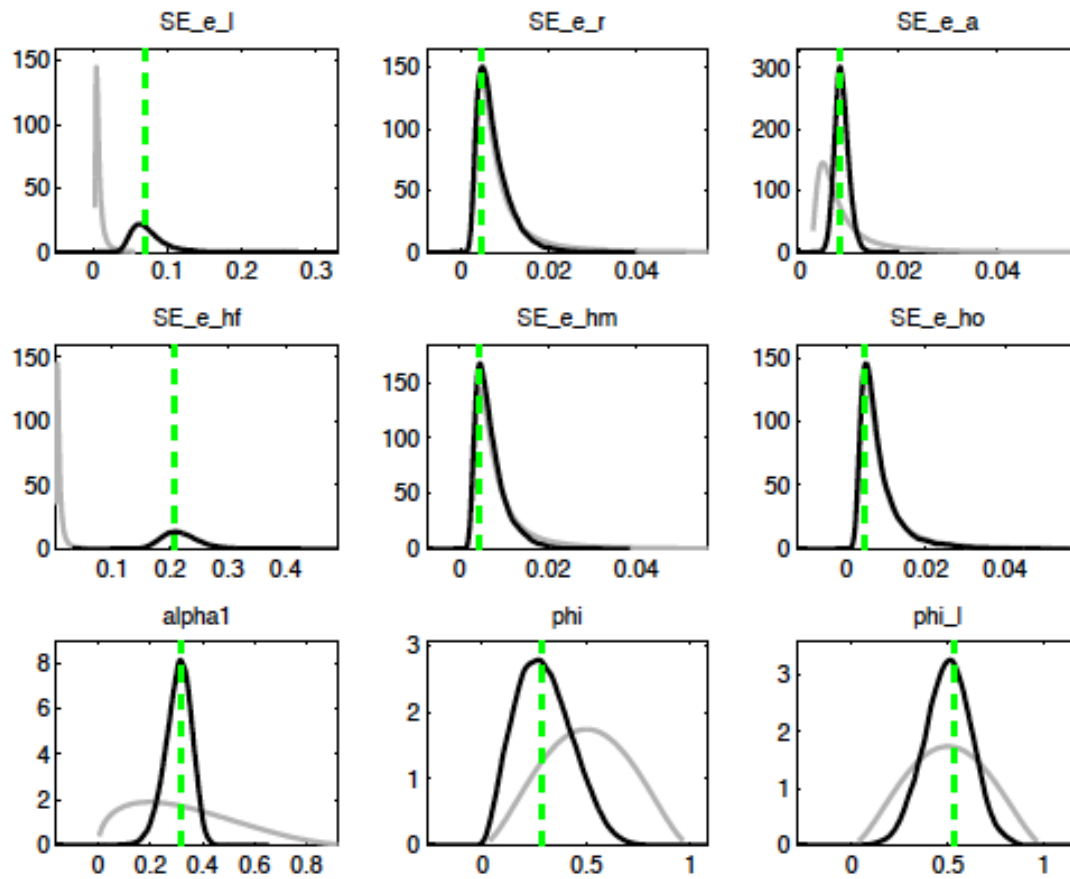
(light line curve is prior distribution, bold line curve is posterior distribution)

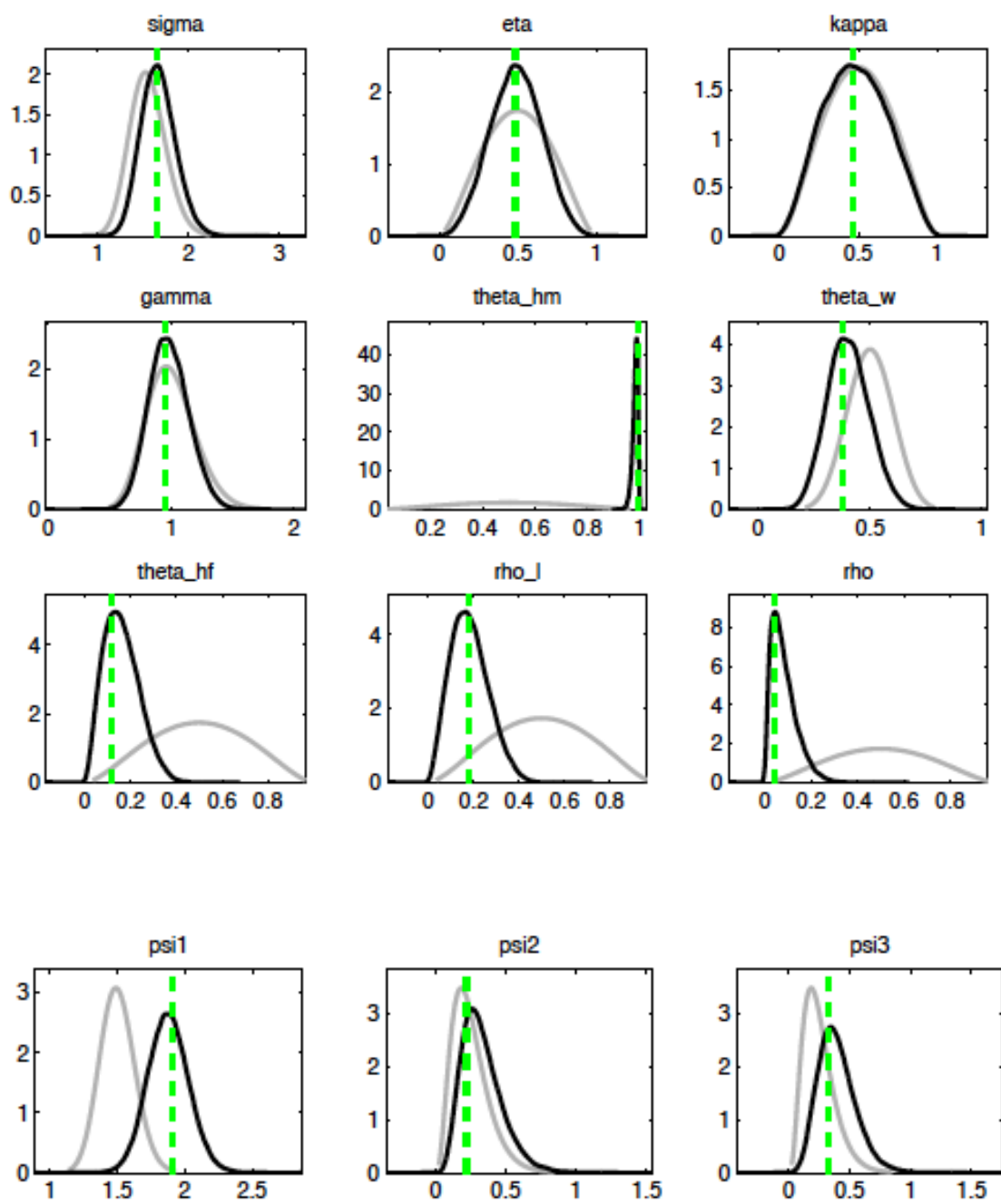




Philippines

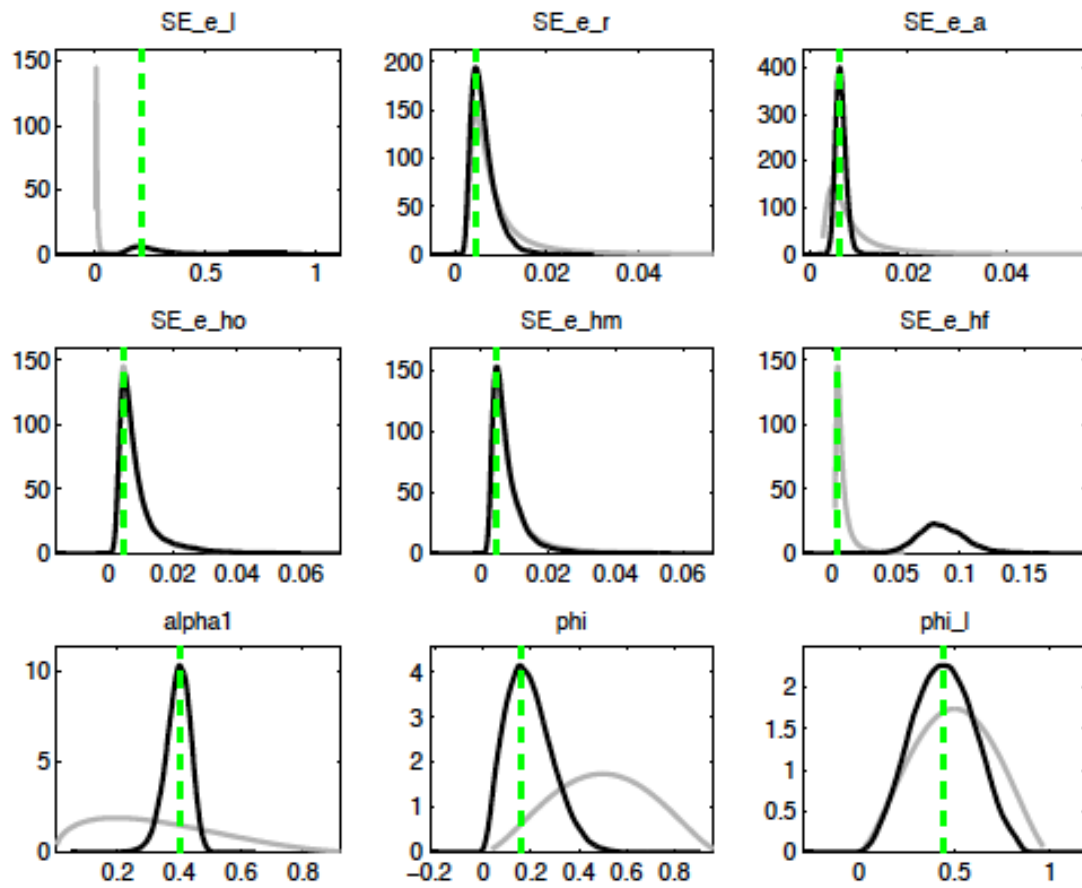
(light line curve is prior distribution, bold line curve is posterior distribution)

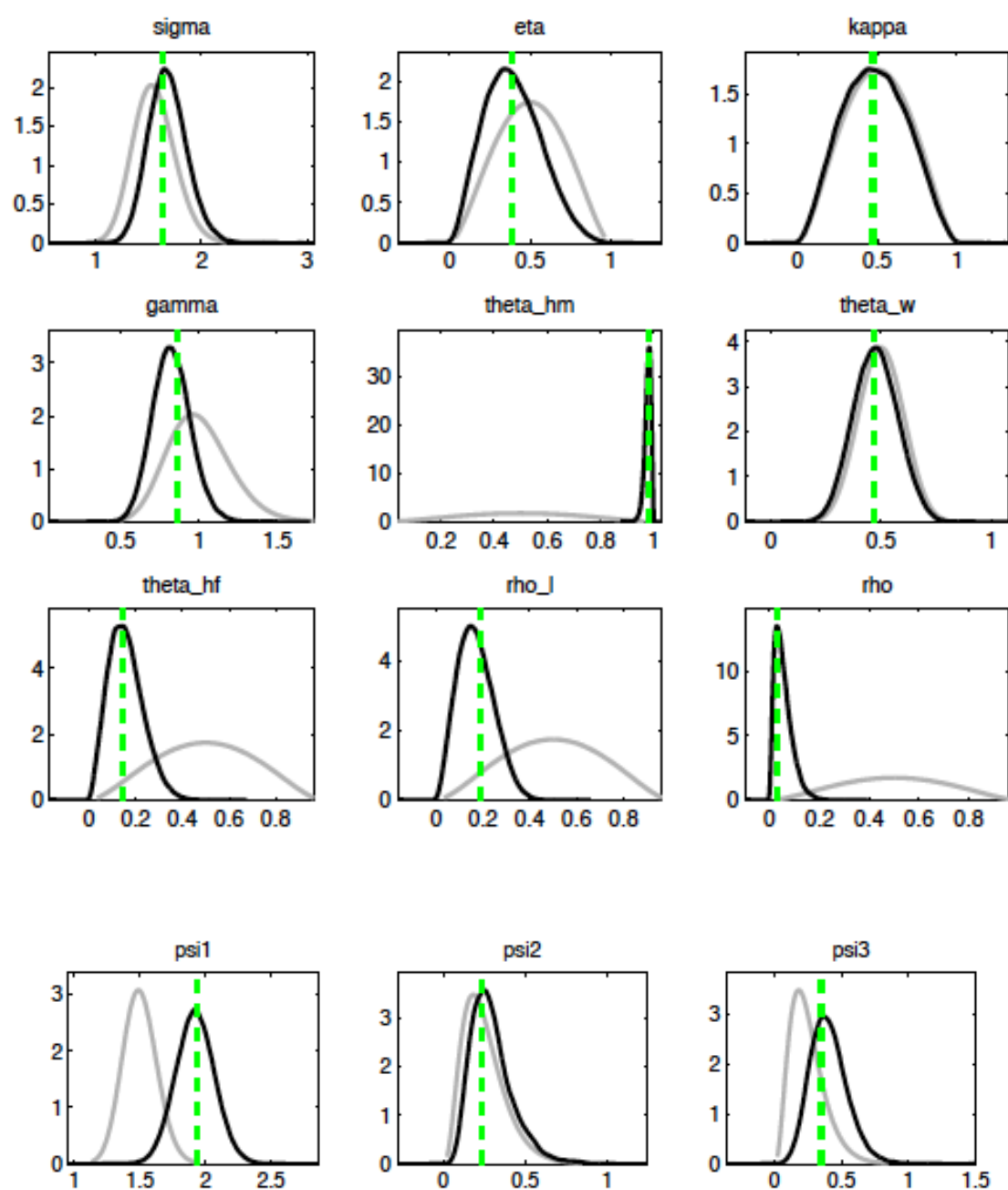




Thailand

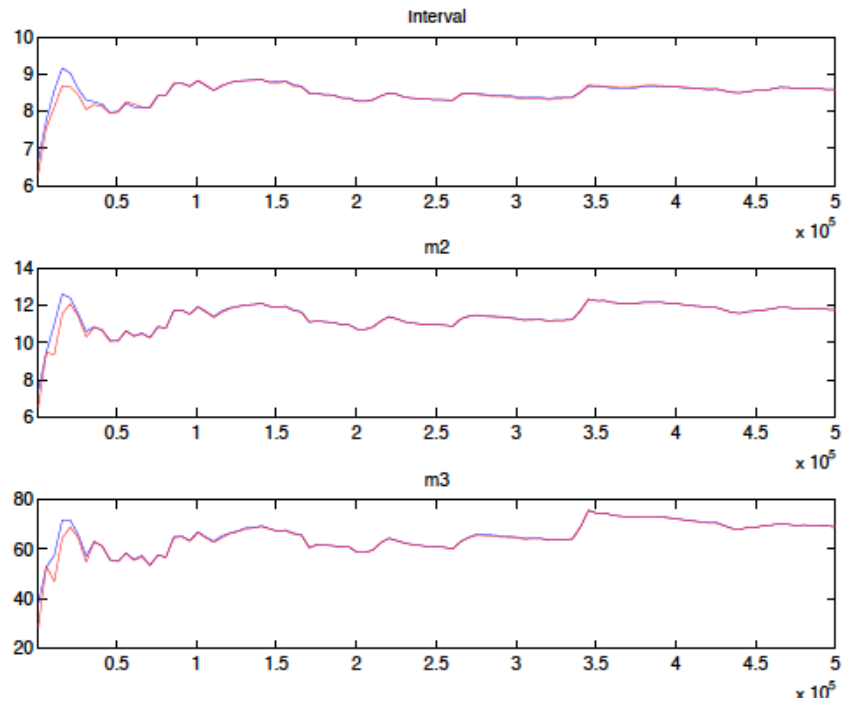
(light line curve is prior distribution, bold line curve is posterior distribution)



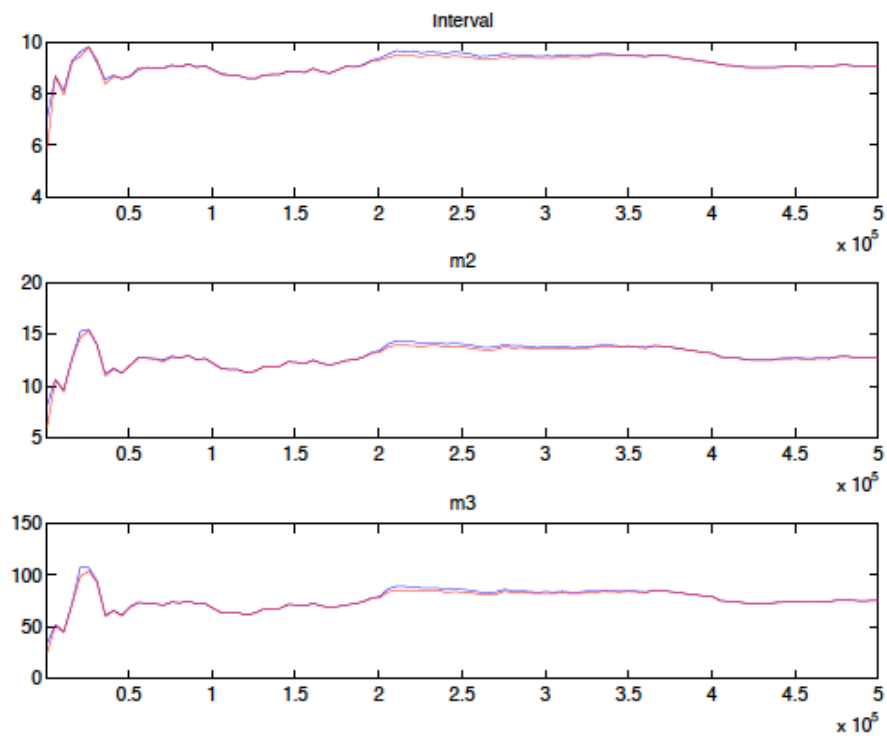


Appendix 4.5. Markov Chain Monte Carlo (MCMC) Diagnostic Check (Multivariate Convergence Diagnosis)

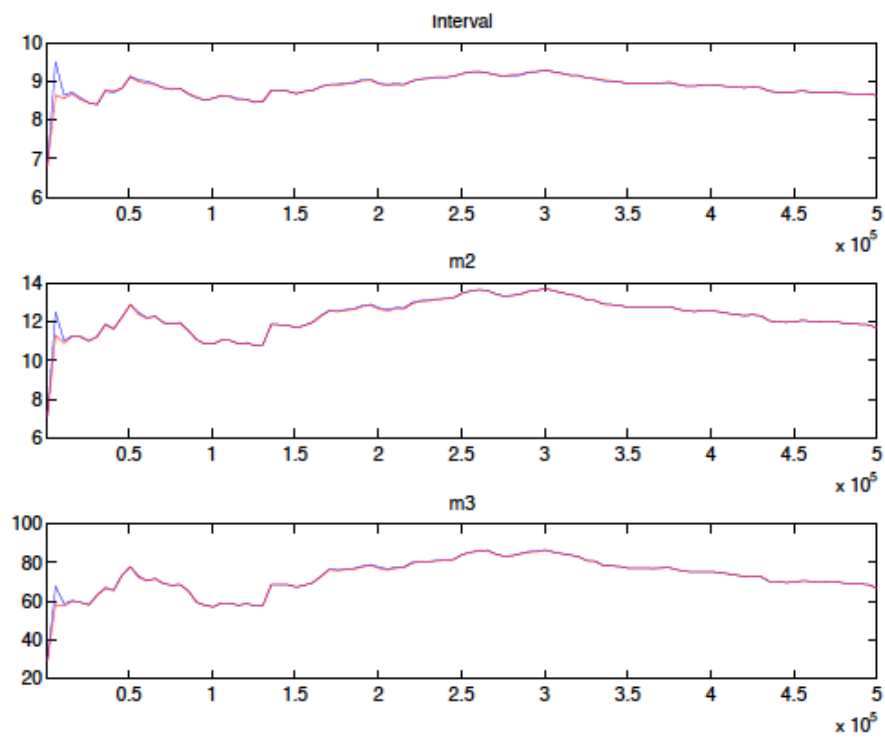
Indonesia



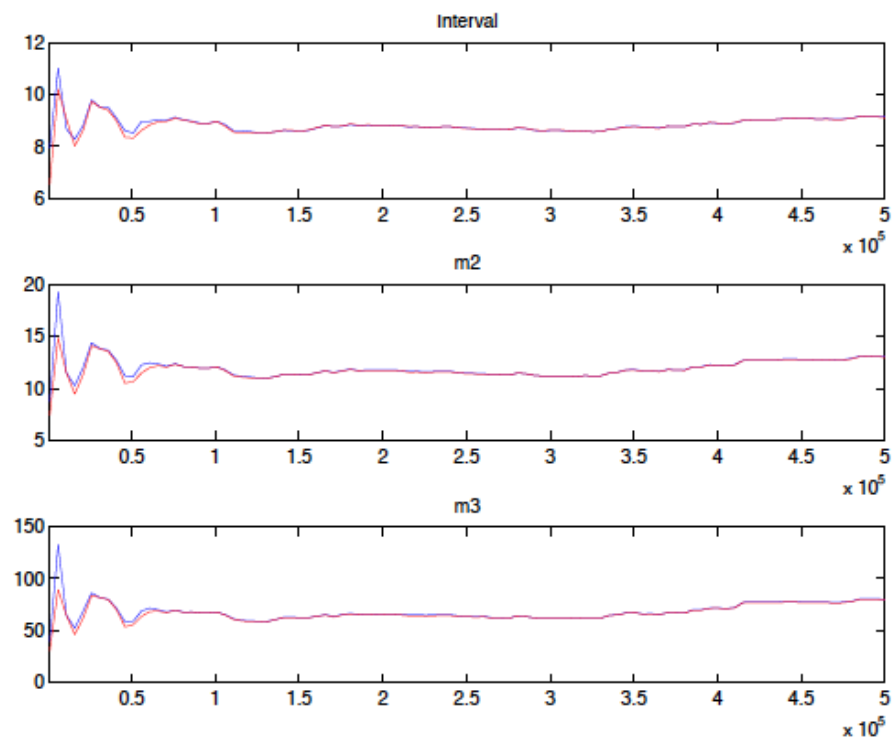
Korea



Philippines



Thailand



Chapter 5

The Dynamics Of Indonesian Inflation: What We Can Learn From Inflation Disaggregation

5.1. Background and Motivation

The main objective of monetary policy in the framework of Inflation Targeting is to keep prices stable, which requires a thorough knowledge of price behaviour. Without sufficient knowledge of this, policy makers will face difficulties in formulating appropriate monetary policy. Previous chapters have evaluated some important aspects of inflation dynamics of various Asian countries. We have measured inflation persistence, exchange rate pass through and the impact of world commodity price shocks upon domestic prices. All of these focus on inflation dynamics at an aggregate level. None of the previous chapters has explored inflation dynamics at the most disaggregated level.

To complete the work of the previous chapters, the emphasis of this chapter is on the study of inflation dynamics at a disaggregated level. Unlike the previous chapters, which have examined several countries, here we focus just on one country. There is a trade off between the detail of the data and the number of countries that can be accessed. Comparative studies of a number of countries are most likely to use aggregate data because these are usually only accessible at an aggregate level. On the other hand, we can go into detail on a certain variable provided we have the data in detail. In this case, it is usually impossible to obtain inflation data at a disaggregated level country by country. Moreover, the data are strictly confidential. This chapter focuses only on Indonesia's inflation dynamics, the data for which have been made available to the author, although they are still strictly confidential.

The conclusions derived from analysis using aggregated and disaggregated prices may be different. For instance, Christiano, Eichenbaum and Evans (1999) find that prices are sticky at an aggregate level. It does not respond substantially to unanticipated monetary policy shock for one and a half years. On the other hand, Bils and Klenow (2004), who examine 350 categories of goods and services, find that prices in the US are much more volatile. Bunn and Ellis (2012), who examine price behaviour in the UK using micro data conclude that the frequency of price changes is not fixed over time. Golosov and Lucas (2007) also use micro data from Bils and Klenow (2004) to calibrate their menu cost model. They again find that prices are more flexible. Using disaggregated data on price indices, Boivin, Giannoni and Mihov (2009) are able to explain why the impulse responses of aggregated and disaggregated prices are different. They conclude that one should distinguish the source of the shocks. The rigidity found at the aggregated level is influenced by macroeconomic shocks, while the flexibility found in the disaggregated level is related to sector specific shocks.

These different explanations imply that it is desirable to use a more detailed data set. A richer and more thorough analysis can be conducted, and hence more accurate policy recommendations can be derived. Using disaggregated level data in general, the objective of this chapter is to answer some fundamental questions:

1. What is the extent of price flexibility in Indonesia?
2. What is the response of inflation at an aggregated and disaggregated level to monetary policy shocks?
3. What policy implications can be derived from this analysis?

Given the above research questions, the contribution of this chapter should be of greatest value for policy makers, as the empirical findings could help to guide them when

setting their monetary policy. Moreover, this is the first analysis to use disaggregated Indonesian price data using FAVAR. In terms of the methodology, some modifications and combinations of data also contribute new insights to the literature.

The remainder of this chapter consists of five sections. The following section is a literature review, which describes the main research on disaggregated prices. Section 5.3 explains the methodology employed. Section 5.4 briefly explains the measurement of CPI in Indonesia and describes the data employed. After the methodology and data section, the empirical findings are presented in section 5.5. Section 5.6 provides the conclusion and policy implications.

5.2. Literature Review

The fundamental question about the extent of price stickiness is one of the central debates in the extensive macroeconomic literature, in which it is agreed that monetary policy changes have transitory effects on the volume of goods and services because of price stickiness. The magnitude and the persistence of the effects vary and depend on the degree of price stickiness. The literature in general uses aggregate data for prices. It finds that aggregate prices do not respond to an unanticipated monetary policy shock immediately, but with some lags. For instance, Christiano, Eichenbaum and Evans (1999) record that with various identification in their VAR model, the aggregate price does not respond for approximately 18 months after an unanticipated monetary policy shock or monetary contraction, and then starts declining. As more detailed price data becomes available, the research that explores these micro data has been growing substantially. Some support the previous findings; others find contrary results. In this section, we review some of the relevant literature.

We start with Bils and Klenow (2004), henceforth BK, who examine price behaviour in the US. They focus on whether prices are more flexible or rigid. The paper uses unpublished data from the Bureau of Labor Statistics (BLS) covering the period 1995-1997 and divides them into 350 categories of goods and services. The data represent around 70 percent of consumer expenditure. To measure the price changes, they use a simple average of the monthly frequencies of price changes in 1995, 1996 and 1997 of each item. This is calculated by the percentage of how many times the price of each item changes between 1995 and 1997. The frequency is in months and is divided by the number of months in the period 1995 to 1997 to find its percentage. Their research finds that the prices of both durable and nondurable goods change more than the prices of services. Among the seven subgroups of CPI, the most flexible one is transportation. On the other hand, the most inflexible is the price of medical and entertainment subgroups. When it comes to the classification of raw goods and processed food, they find that raw goods exhibit more flexibility. In relation to the market structure, they conclude that market power, which is represented by a concentration ratio or a wholesale mark up, cannot explain the frequency of price changes. By focusing on the frequency of price changes, they undermine the time dependent based sticky price model. At the same time, they observe the inflation volatility and persistence of 123 goods by employing an AR (1) process. BK find that many more goods and services witness prices changes and move frequently than in previous studies. They also reveal that there is a positive correlation between volatility and inflation persistence. Goods that change price more frequently or exhibit more volatility have more serial correlation or exhibit higher inflation persistence. This contradicts what a time dependent model, such as the Calvo model, predicts.

Bils and Klenow (2004) treat sales prices as price changes. As a result, across the whole consumer price index they find the median duration of price changes is around four months. On the other hand, Nakamura and Steinson (2008) find that the median duration is around nine months if sales are excluded. This difference raises the question on how great the effect of monetary policy should be on real variables, since this effect depends on price stickiness. Meanwhile, price stickiness depends on the treatment of sales. Guimaraes and Sheedy (2011) build a DSGE model with sales to examine whether monetary policy matters when normal prices are relatively sticky amid frequent price changes due to sales. Their initial model has two household types: loyal customers who have low price elasticity and bargain hunters who are very sensitive to price changes. They compare the results with a standard sticky price model without sales. In general, the real effects of monetary policy in both models are similar. The cumulative response of output in the model with sales is around 89 percent of that of the standard model. To accommodate the fact that sales are frequent in one sector and very rare in another, they also develop their model with two sectors: one sector features sales, while the other features standard pricing without sales. Again, the results are similar in comparison to the standard model. They conclude that sales do not matter for the analysis of the effect of monetary policy.

Bils, Klenow and Kryvtsov (2003) set up a simple general equilibrium model to examine whether flexible price goods and sticky price goods respond differently to monetary shock. They classify consumption into two types of goods, namely flexible and sticky price ones. Based on the simulation of their model they conclude that, contrary to what is commonly predicted, following an unanticipated cut in the interest rate, the prices of flexible goods not only change but also paradoxically tend to decline relative to the price of sticky goods.

Golosov and Lucas (2007) support the view that prices are more flexible in facing shocks. They construct a menu cost model and use micro data for calibration purposes. The data are the same as in BK (2004), covering seventy percent of the US CPI. The calibration is based on some moments of these micro data. Their model incorporates aggregate inflation shocks as well as idiosyncratic productivity shocks. The introduction of the idiosyncratic shocks mimics the frequency of price changes in the data, which cannot be explained by the aggregate shocks only. Their model predicts that the impulse responses of output, employment and prices are short-lived when facing these two shocks, that they are less persistent. Regarding prices, a positive aggregate shock that leads to a higher price will adjust the boundary of the firms that want to reset their prices. This asymmetric feature changes the number of firms that reset their prices; more firms want to increase their prices after the positive aggregate shocks. As a result, the aggregate price will increase, and this happens very quickly. On the other hand, the same shocks in the Calvo model do not generate similar impulse responses. The explanation is that the number of firms that want to change their prices is fixed, regardless of different conditions. As a result, the aggregate prices will not change as much as in the menu cost model.

As regards a suitable model to explain price behaviour, Bunn and Ellis (2012) examine this behaviour in the UK. In particular, they investigate the frequency of price changes, using two sources of data, to examine whether a time dependent or a state dependent model can better explain price behaviour. The first data set is monthly prices quoted to construct CPI and the Retail Price Index (RPI). The second type of data is weekly supermarket data. To observe whether the frequency of price changes is fixed over time, as implied by a time dependent model, they calculate the magnitude of changes with different samples of their micro data. They find that the strict time dependent model is

inconsistent with the data, as the frequency of price changes varies over time. However, from the magnitude of price changes they also suggest that a single state dependent model, whether a menu cost model or a quadratic cost model such as that of Rothemberg (1982), may be unable to explain the price setting behaviour of most firms. Bunn and Ellis further construct hazard functions that are calculated from the ratio of share of price changes observed in the current period to share of price that has not changed in the previous period. If this function is flat, this implies consistency with the prediction of the time dependent models; if not, with those of state dependent models. Their hazard functions exhibit heterogeneity. For instance, the hazard function of goods prices is downward sloping, while that of service prices is relatively flat. In short, they conclude that the price setting behaviour is heterogeneous, so as a result no single existing price setting model can perfectly capture price behaviour at an economy-wide level.

In addition to this research, Balke and Wynne (2007) provide an interesting insight into the movement of inflation at the disaggregated level. They argue that monetary non-neutrality should reflect on the movement of the relative prices after monetary shock. To investigate this, they employ more than 600 monthly change components of the producer price index (PPI) in the US from 1959M1 to 2001M12. First, they estimate a VAR model that consists of some macro variables. To observe the impulse response of each individual price they append the equation of the individual component of PPI in the VAR model. The equation of the individual price is:

$$p_{it} = A_i x_t + B_i(L)p_{it-1} + C_i(L)Y_t + \varepsilon_{it} \quad (5.1)$$

where p_{it} is the log of the component of PPI, x_t is the constant and seasonal dummy variables and Y_t is the macro variable that represents unanticipated monetary shocks. The response of each price to monetary shocks is then used to construct their cross section

distribution of price changes at each point in time. By looking at the selected moments they conclude that the effect of monetary shock is widespread across prices. This reflects an increase in the variance and a decline in the kurtosis and skewness of the distribution. The results also show that the contractive monetary shock moves the distribution toward a lower price level over time. The price puzzle phenomenon present at the aggregate level also occurs across the individual level of PPI.

Balke and Wynne split the individual prices into final goods, intermediates and raw goods. They observe the response of each category to the monetary contraction shock. Over a short period (12-20 months), higher proportions of the intermediate and final goods display a positive response or their price level tends to increase. Over a longer period, both price levels decline. A larger percentage of the prices of crude goods fall in response to the shock. The main finding of this research is the different responses of individual prices and hence to aggregated prices, given a monetary shock. When it comes to the disaggregated data, it is difficult to capture the phenomenon with some classes of models. In the sticky price or sticky information model, the effects of monetary shock on prices differ. Some are changed, while others are unchanged. However, the direction is the same. This contrasts with the findings of this research, in which some prices fall and others rise. This implies that the assumptions behind the models that try to explain inflation dynamics should be more varied, not only a matter of the frequency of price changes.

Unlike previous research, other research findings provide arguments that support price stickiness by explaining the difference in conclusions between aggregate level data and disaggregated level data. Altissimo, Mojon and Zaffaroni (2007), hereafter AMZ, employ the theory of cross-sectional aggregation of the dynamic process to investigate the relationship between the inflation persistence occurring in the aggregate of inflation and

the volatility in the disaggregated inflation. They use quarterly data for 404 sub indices of the Euro area CPI from 1985 to 2003 to estimate their models. First, they estimate each sub index (y_{it}), namely sectoral inflation, using an AR(1) process with the random shock consisting of a common (u_t) and an idiosyncratic element (ϵ_{it}).

$$y_{it} = \alpha_i y_{it-1} + \eta_{it} \quad (5.2)$$

$$\eta_{it} = u_t + \epsilon_{it}, \quad u_t \sim iid(0, \sigma_u^2) \text{ and } \epsilon_{it} \sim iid(0, \sigma_{\epsilon,i}^2) \quad (5.3)$$

$$Y_{n,t} = \frac{1}{n} \sum_{i=1}^n \frac{u_t}{1-\alpha_i L} + \frac{1}{n} \sum_{i=1}^n \frac{\epsilon_{it}}{1-\alpha_i L} = U_{n,t} + E_{n,t} \quad (5.4)$$

Second, they sum those sectoral inflation estimations into sub groups (Y_{nt}), namely processed food, unprocessed food, non-energy goods, energy goods and services. In addition to this, they also estimate the aggregation based on data from Germany, France and Italy. Finally, they compare the results of these estimations. They find a relationship between high volatility and low persistence at the level of sectoral inflation, and less volatility and high persistence at the aggregate level. Specifically, the cross sectional distribution of the parameters in the estimation of sectoral inflation bears an important relationship with the autocorrelation function of the aggregate inflation rate.

Another paper that supports price stickiness is that of Boivin, Giannoni and Mihov (2009), hereafter BGM. While the AMZ research is based on Euro area data, BGM conduct their research on US consumer and producer price data. The data set used in this research is a balanced panel of 653 monthly series, including prices, for the period from 1976M1 to 2005M6. To examine the disaggregated prices, they employ the Factor Augmented Vector Auto Regressive (FAVAR) technique. This methodology is an extension of the VAR model, based on the work of Bernanke, Boivin and Elias (2005), hereafter BBE. With this technique, they disentangle the effect of a common component

from an idiosyncratic component of the respective prices. The indicator data used to construct the latent factors in their FAVAR are the same as in BBE. However, for prices, BGM use disaggregated ones instead solely aggregated prices. Another difference is that BGM only use a two-step FAVAR¹¹.

They document that the volatility of aggregated prices measured by its standard deviation is related to the common component. The result is dramatically different when it comes to disaggregated prices. On average, most of the volatility in disaggregated prices is related to the idiosyncratic component. Overall, the disaggregated prices are more volatile than the aggregated prices, and are less persistent. There is therefore a negative correlation between volatility and persistence, a finding which conflicts with what BK found.

BGM measure the persistence of common and idiosyncratic components of the prices using an AR model. They conclude that the persistence is highly varied across individual prices and mostly due to persistence in the common component. Meanwhile, the specific sectors display almost no persistence.

BGM also documents the response of the sectoral price level to a shock, specifically its own sector-specific shock, aggregate macroeconomic shock and monetary shock. The prices show different responses given different shocks. By and large, aggregate macroeconomic shocks have a significant and permanent influence on prices. Meanwhile, sector specific shocks only affect prices once and for all.

To analyse the effect of monetary policy shock, BGM apply an identification in their FAVAR system. They assume that the unobserved components or the latent factors do not respond contemporaneously to the change in the Fed Fund rate. The result shows the persistence of inflation across sectors. The prices tend to decline steadily for a couple

¹¹ In Bernanke, Boivin and Elias (2005) two FAVAR models are employed: one step, which uses a Bayesian technique, and two step, which uses a principal component to generate the factors.

of years following the monetary policy shock. Interestingly, the price puzzle that usually occurs in a VAR model disappears in this FAVAR model.

BGM can disentangle the source of a shock, whether it is macroeconomic, including monetary policy shocks, or sector specific shocks. The disaggregated prices respond sluggishly to the former shock; on the other hand, they tend to be flexible in response to the latter. This research therefore provides evidence for the fact that the volatility apparent in disaggregated prices as shown in BK is mostly related to a sector specific shock. It is not because of macroeconomic shocks, especially a monetary policy one.

Mumtaz, Zabczyk and Ellis (2009), hereafter MZE, follow the ideas of BGM and apply them to UK data. MZE use disaggregated consumer expenditure data and sixty sets of macroeconomic UK series data between 1977Q1 and 2006Q3. Technically, they enhance the way of constructing the factors in FAVAR. In their baseline model, they construct them using all the data and without separating them into particular blocks. In their alternative model, they separate the data into certain blocks: real activity, inflation, money and asset prices. In order to do this, they apply sign restrictions using Bayesian estimation. For the benchmark, they also estimate a standard five-variable VAR with CPI inflation, GDP growth, M4 growth, the UK sterling exchange rate index (ERI) and Bank Rate. Their baseline model consists of eight factors and uses Cholesky decomposition¹². Using this model, they find, in contrast to the BGM results, that the price puzzle still exists: the mean of CPI increases after a monetary contraction. The delay in the reaction of median inflation is almost two years. This is also different from the structural model of the UK, which shows a one to two year lag. Based on this, they check the robustness of the

¹² Cholesky decomposition is a restriction to identify a VAR system. This restriction decomposes the residual in a triangular fashion that determines which shock affects another contemporaneously (Enders, 2004)

result using sign restriction in their FAVAR model. With this technique, the price puzzle disappears. Other than that, their findings are similar to those of BGM. The volatility for most disaggregated prices is mainly influenced by sector-specific shocks, rather than macroeconomic ones. Their findings also suggest that there is no relationship between persistence in the aggregate consumption deflator and the average persistence of the related component disaggregated deflator. Persistence in either aggregate or disaggregated prices is less influenced by sector-specific factors. In other words, the persistence in prices is mainly due to macroeconomic shocks, such as activity or policy changes.

There is also a survey on price rigidity in the case of Indonesia (Solikin and Sugema, 2004). The aim is to look at price determination in manufacturing firms, wholesalers and retailers. 220 consumer goods producers covering 194 groups of products are included in the survey. In general, the main determinants of price setting in Indonesia are factors that are related to the supply side, such as a firm's costs. Prices are likely to change if the cost structure of the firms also changes. Around 66 percent of the firms determine prices based on direct cost and mark up. The remainder are determined by other variables such as competitor price and regulation. For wholesalers and retailers, the ratio is around 75 percent. The demand factor is less influential for the price setting of the firms. Only 15 to 17 percent of them adjust their prices if demand changes. Most tend to adjust their production rather than adjust their prices. The domination of the cost factor is also reflected in the speed of price adjustment. More than 75 percent of the respondents would change prices within a month if there were changes in the cost of production. The survey also shows that firms, wholesalers and retailers change prices infrequently, twice a year or less than that. They tend to adjust their margin if there are cost structure changes and if

there is a price change, it changes asymmetrically. Prices tend to increase if there are cost increases, but not vice versa, or there is downward rigidity.

From the review of the research above, the main point is that it is essential to scrutinise not only the aggregate level of inflation, but also the disaggregated level. In that way, we can reach a deeper understanding of the movement of inflation in a certain sector due to a certain shock. The FAVAR technique that is applied in BGM accommodates this. This technique is able to analyse prices at both aggregate and disaggregate levels in the same framework simultaneously. In the following section, we describe this technique in more detail.

5.3. Methodology

There are many methodologies for evaluating inflation at an aggregate level. In the previous chapters we have employed a range of these. Meanwhile, evaluation of inflation data at a disaggregated level requires a specific methodology. We employ a Factor Augmented Vector Autoregressive model, henceforth FAVAR, for various reasons. One main advantage is that FAVAR allows us to include many variables without worrying about the curse of dimensionality.

FAVAR models are Vector Autoregressive (VAR) ones that are augmented (A) by latent dynamic factor (F) variables. Dynamic factor models are used when macroeconometricians face a degrees of freedom problem because the number of series exceeds the number of observations. The premise of dynamic factor models is that a large number of series can be represented by a few latent factors and idiosyncratic disturbances. These latent factors represent comovement of the series and follow time series processes, usually VAR processes. Meanwhile, idiosyncratic disturbances are any factor that is

specific to a single series. This also includes measurement errors of the series. Mathematically, a dynamic factor model is represented as follows:

$$\mathbf{X}_t = \boldsymbol{\lambda}(L)\mathbf{F}_t + \mathbf{e}_t \quad (5.5)$$

$$\mathbf{F}_t = \boldsymbol{\Psi}(L)\mathbf{F}_{t-1} + \boldsymbol{\eta}_t \quad (5.6)$$

\mathbf{X}_t is the vector of the N series and \mathbf{e}_t are the idiosyncratic disturbances, so both are $N \times 1$. There are K latent factors \mathbf{F}_t , so that \mathbf{F}_t and $\boldsymbol{\eta}_t$ are $K \times 1$. As a result, $\boldsymbol{\lambda}(L)$ and $\boldsymbol{\Psi}(L)$ are $N \times K$ and $K \times K$ respectively. The i^{th} lag polynomial $\lambda_i(L)$ is the dynamic factor loading of the i^{th} series X_{it} . The common component of the i^{th} series X_{it} is $\lambda_i(L)f_t$. The processes in equations (5.5) and (5.6) are assumed to be stationary. The idiosyncratic disturbance e_t and the factor innovation η_t are also assumed to be uncorrelated at all leads and lags, so that $E(e_t \eta'_{t-j}) = 0$ for all j , positive or negative.

One of the main issues in this framework is how to estimate the factors. According to Stock and Watson (2010), there are three generations of factor models. The first generation approach deals with the low dimension of series. It uses Maximum Likelihood and Kalman filter to generate the factors. These estimate optimal factors under the model, and with the assumed parameters. However, this entails nonlinear optimisation, which restricts the number of parameters, and hence the number of series. The second generation approach deals with a large number of series and uses a non-parametric averaging method such as principal components and related methods. The third generation approach combines the consistent non-parametric estimation in the second generation with the first generation approach. It employs Bayesian methods to solve the dimensionality problem faced by the first generation approach.

This chapter uses principal component analysis to estimate the factors, as adopted in BGM. Principal component analysis estimates the factors by identifying the patterns of a large number of series and expressing them based on their similarities. In brief, the steps in this method are as follows:

- a. Normalise the series by demeaning, or subtracting them from their mean.
- b. Calculate the covariance matrix of the series and find the eigenvectors and eigenvalues of the covariance matrix. These eigenvectors must be of unit length.
- c. Order the eigenvalues from the highest to the lowest, then form a feature vector, which is constructed by taking the eigenvectors that we want to keep from the list of eigenvectors. The number of eigenvectors we keep in this vector determines how many factors we want to estimate.
- d. Form a matrix with these eigenvectors in the column or row feature vector. The new data or factors are the multiplication of the row feature vector and the adjusted data.

The factors generated summarise all the series, while capturing most of their variation. Once one has estimated the latent factors, one can use these for forecasting, using them as instrumental variables, or estimate a FAVAR model.

The FAVAR model was initially proposed by BBE (2005). This model follows a VAR model and uses observable variables and factors as variables in the VAR. The augmented term refers to the factors that are included in the VAR system. BBE (2005) apply two approaches in estimating their FAVAR: one step, which employs Bayesian techniques; and two step, which uses principal component analysis to estimate the factors.

BBE (2005) use FAVAR to measure the effects of monetary policy, instead of the VAR that is commonly used to measure this effect. BBE (2005) note that there are three disadvantages of VAR models. First, a VAR model may not include all the variables used

by the central banks or private sector. Due to the problem of degrees of freedom, a VAR model usually only employs a few variables. On the contrary, central banks or private agents usually watch a large number of indicators. As a result of the use of only a few variables, a shock to a policy variable can be contaminated. For instance, policy tightening is not purely an exogenous shock. It is partly because of anticipation of inflation pressure in the future that is not controlled for in a VAR model. This creates what is widely known as a price puzzle; monetary contraction is followed not by declining prices but rising ones (Sims, 1992). Second, a VAR model typically uses variables that are observable with some degree of error or that can only be approximated. For instance, real economic activity may be not precisely captured by observable variables such as production indices or real GDP. It is also justified by some assumptions such as measurement error, real time data and revisions. This is even true for variables such as CPI and GDP. Given this, we need an approach to capture these unobservable variables in a more comprehensive and precise way. The third caveat of VAR is that it can only generate a limited number of impulse responses of the variables, as only a few variables are included. Meanwhile, policy makers usually want to see the impulse response of many variables so that their decisions can be more comprehensive.

BBE (2005) propose FAVAR to address these drawbacks. By employing a few factors that can summarise a large number of series, it can address the degree of freedom problem. These factors also solve the unobservability problem by using many variables that approximate the unobservable ones. The third problem is also answered; by employing many variables, impulse responses of many variables are provided to the policy makers. A FAVAR model can be formulated as follows:

$$\begin{bmatrix} \mathbf{F}_t \\ \mathbf{Y}_t \end{bmatrix} = \Phi(L) \begin{bmatrix} \mathbf{F}_{t-1} \\ \mathbf{Y}_{t-1} \end{bmatrix} + \mathbf{v}_t \quad (5.7)$$

where \mathbf{F}_t is the $K \times 1$ vector of unobservable factors and \mathbf{Y}_t is the $M \times 1$ vector of observable variables. The error term \mathbf{v}_t is i.i.d. with mean zero. Equation (5.7) is a reduced form of a VAR equation with $\Phi(L)$ as the lag polynomial. A FAVAR model refers to this equation. It nests a standard VAR but is augmented with additional information contained in the factors. If the true system is a FAVAR but we estimate a standard VAR, which is equation (5.7) consisting of \mathbf{Y}_t only, we end up with spurious estimators.

However, we cannot solve equation (5.7) directly without knowing the unobservable factors. We need to generate them. As already mentioned, the factors are the summaries of a large number of series. Hence, we can generate the factors from those series. Suppose we have a vector of informational variables \mathbf{X}_t , $N \times 1$, where N is the number of series included. The relationship between the series (\mathbf{X}_t), the factors (\mathbf{F}_t), and the observable variables can be formulated as follows:

$$\mathbf{X}_t = \Lambda \begin{bmatrix} \mathbf{F}_t \\ \mathbf{Y}_t \end{bmatrix} + \mathbf{e}_t \quad (5.8)$$

where Λ is the $N \times (K + 1)$ matrix of the loading factors. The first part of the right hand side of this equation is the common component of the series and the last part (\mathbf{e}_t) is the $N \times 1$ matrix of the idiosyncratic component. The series of common components are uncorrelated with those of idiosyncratic components. Equation (5.8) allows us to extract the factors, given the indicator series and the observable variables. The general term of equation (5.8) may involve the lags of the factors, as in equation (5.5) of the dynamic factor model.

The shocks imposed on these two components are macroeconomic shocks and sector specific shocks respectively. By definition, a sector specific shock refers to a shock that is only imposed on one series. For example, a shock to a certain world commodity

price might only influence a certain domestic commodity price. At least it should not influence other domestic commodity prices directly or significantly. Meanwhile, a macroeconomic shock could influence all prices, hence it is called a common shock. A shock to a macroeconomic variable such as the exchange rate or a policy change could influence the movement of all individual prices.

As in BGM, we shall focus on the behaviour of disaggregated prices. Hence we shall involve disaggregated price series in \mathbf{X}_t . In addition to this, we are interested in the effect of monetary policy shock on the disaggregated price series. For that, we replace \mathbf{Y}_t with the interest rate (R_t) as the observable variable. We follow a two-step approach, as in BGM. First, we extract the series using principal component analysis to obtain the latent or common factors \mathbf{F}_t . In the second step, we add policy rate R_t and estimate the system VAR as in equation (5.7). We follow recursive identification with the order $[\mathbf{F}_t, R_t]'$; with this identification the interest rate R_t is influenced contemporaneously by the common factors \mathbf{F}_t . Meanwhile, the common factors react to the interest rate with a lag. We can interpret the last equation of the VAR as a contemporaneous interest rate rule.

We follow Bai and Ng's (2002) information criteria to determine how many factors are properly included. This method is suitable for a large number of series and observations. This method also allows for both limited time series and cross-section dependence, and for heteroskedasticity in the time series and cross section in the idiosyncratic component. For the lags, we employ information criteria commonly used to estimate a VAR model.

5.4. Data

In this analysis we use disaggregated data from CPI. The basic material of the measurement of CPI is the cost of living survey. Statistics Indonesia or Badan Pusat

Statistik (BPS) has conducted a cost of living survey since its inception in 1977/1978. The interval between surveys is not fixed, but depends on the condition of the economy. The objective is to know what type of goods households are consuming, at what level, and the weight of the goods consumed. There are some criteria for which goods are included in the survey. Examples include the minimum percentage of consumption value to total consumption, the goods and services which are those that need to be among the ones most consumed during the period of the survey, and the price of the goods and services must be observable during the period of the survey.

The goods and services are finally divided into seven groups: foodstuffs; processed food, beverages, cigarette and tobacco; housing, water, electricity, gas and fuel; clothing; medical care; education, recreation and sport; transportation, communication and financial services. No interest rate related services, such as consumer credit charges or mortgage interest rate payments, are included in the CPI. Based on the results of the cost of living survey, BPS conducts its price survey periodically and calculates the CPI. The cost of living survey becomes a base for that. Statistics Indonesia obtains consumer or retail price data from 66 cities and now covers 744 goods and services, which are classified into the seven major groups detailed above.

The data employed in some research consist of data for individual prices that are collected and used to calculate CPI; these are called micro data. We do not employ these micro data, but follow BGM, who use disaggregated of CPI. We use monthly data from 2002 to 2011, which are based on the 2007 cost of living survey. We back cast the 2007 data to the 2002 base year, based on month-to-month growth of the data of the 2002 base. Given the two cost of living surveys (2002 and 2007) during the period of estimation, we do not use all the disaggregated prices, but all price data in the 2007 base that are also

present in the 2002 base. Unlike BGM, we group the series into the CPI that includes all individual, core and non-core prices. These generate monthly headline inflation, core inflation and non-core inflation respectively. The reason for this is that we can identify the impulse responses of these groups. In particular, we can observe the impulse responses of core inflation in facing monetary policy shocks. By definition, core inflation is influenced more by fundamental factors such as monetary policy. Overall, the disaggregated prices included cover around 96 percent of the components of the CPI, comprising 63.6 percent of core prices and 32.4 percent of non-core prices.

In addition to disaggregated prices we also use certain indicators to construct the factors. These indicators include demand factors such as sales data; production factors such as the production index; exports and imports; monetary data; world commodity prices; interest rates and exchange rates. Some data are interpolated if the available data are quarterly. These include real GDP and its components. We include this combination of disaggregated CPI and indicators to construct the latent factors using Principal Component Analysis in the spirit of equation (5.8). In total we use data on 663 individual prices and 92 indicators, with 118 observations within the period 2002M3 to 2011M12. For comparison, BGM use 111 indicators, 154 PPI series, 194 PCE deflator series and 194 PCE deflator quantity; in total 653 series, with 353 observations for each one.

We seasonally adjust the data for the individual prices and transform many of them. The transformations include the difference of the logarithms of the variables and first differences. Some of the data are not transformed. The mnemonic, transformation and other descriptions of the data are provided in Appendix 5.1.

5.5. Estimation Results

We run the estimations using the MatLab code created by BGM with some modifications to permit consistency with our case. For the information criteria in Bai and Ng (2002) we use the MatLab code created by Schumacher and Breitung (2008). Bai and Ng's (2002) criteria shows if we only include price data, the factor is only one. If we only include the indicators, we obtain four factors to represent them. However, if we include both the price data and the indicator data we obtain one factor. Our guess is that this is because of the domination of price data. We have data on 663 prices and 92 indicators. This domination is also evident when we estimate only certain groups of prices. If we only use one factor, that factor may represent the prices closely, but may display no link with other indicators. Based on this, we have chosen five factors. As a result, in the system of equations 5.7 and 5.8 we have five factors and one observable variable.

The Likelihood Ratio test (LR), the Final Prediction Error test (FPE) and the Akaike Information Criterion (AIC) point to 4 lags. The Schwarz Criterion (SC) and Hannan-Quin (HQ) show 2 lags. We choose 4 lags based on the result of these five criteria. Moreover, with 4 lags we can capture the dynamics between quarters. However, we also estimate the model using a different number of factors for the shake of robustness. We try 4, 6 and 8 factors with four lags. For the lags, we also try 2 lags with five factors; the results are not significantly different. We do not try one lag since no information criteria justify the use of only one in this estimation.

Given the formulation of equation (5.8), we can analyse inflation behaviour at a disaggregated level. Equation (5.8) implies:

$$\pi_{it} = \lambda'_i \mathbf{C}_t + e_{it} \quad (5.9)$$

This equation states that inflation (π_{it}) can be explained by its common component ($\lambda'_i C_t$) and its sector specific component (e_{it}). FAVAR allows us to separate these two components of inflation and analyse their behaviour.

5.5.1. Volatility and the Persistence of Inflation

First, we compare the statistics of aggregate and disaggregated inflation in terms of volatility and persistence. These two statistics are fundamental in assessing price behaviour, in particular as to whether prices are more rigid or more flexible and how they respond to shocks. This behaviour is important for the monetary policy aspect; in particular, it can give illuminate the role of monetary policy in inflation.

Table 5.1 summarises these two statistics. Using standard deviation as a proxy of volatility, we find that the volatility of disaggregated inflation is higher than that of aggregate inflation. The standard deviation of CPI inflation is 0.791, while that of disaggregated CPI inflation is 2.453 on average. This can be explained by the fact that sector specific volatilities tend to cancel each other out, so the volatilities in aggregate inflation decline. The main factor in inflation volatility is the volatility of the sector specifics. This is a fact in both aggregate and disaggregated inflation. R^2 statistics, which measure the ratio of variance of the common component to that of inflation, show that the common components only explain less than 50 percent of the volatility of inflation. If we compare the R^2 statistics for core and non-core inflation, they are higher for core inflation. This implies that the common component plays a greater role in core inflation than in non-core inflation volatility. In other words, the shocks to macroeconomic variables play a more important role in core inflation volatility than non-core inflation volatility.

Table 5.1 also shows heterogeneity in terms of volatility across the inflation sector. The range is from 0.003 to 25.809 percent, with an average of 2.453 percent. If we

examine the group of core and non-core inflation, the volatility is higher in non-core inflation, as expected. This relates to the inflation rate for food, transportation and cigarettes (which are among the administered prices). Increased excise on cigarettes and reductions in fuel subsidy in the period of investigation are the causes.

Table 5.1. Volatility and Persistence of Monthly Inflation Series

	Standard Deviation (in percent)			R ²	Persistence		
	Inflation	Common components	Sector specifics		Inflation	Common components	Sector specifics
<i>Aggregated series</i>							
CPI	0.791	0.251	0.750	0.101	0.234	0.855	0.134
Core	0.308	0.137	0.276	0.198	0.358	0.833	0.567
Vol. Food	1.345	0.481	1.256	0.128	0.196	0.728	0.906
Adm. Prices	2.421	0.674	2.325	0.078	0.085	0.951	0.893
<i>Disaggregated series - CPI</i>							
- Average	2.453	0.837	2.256	0.202	0.003	0.430	-0.119
- Median	1.260	0.529	1.100	0.153	0.034	0.508	-0.095
- Minimum	0.003	0.000	0.003	0.008	-2.192	-1.043	-1.590
- Maximum	25.809	6.914	24.991	0.866	0.853	0.897	0.724
- Standard deviation	2.967	0.894	2.869	0.167	0.396	0.345	0.338
<i>Disaggregated series - Core</i>							
- Average	1.271	0.511	1.132	0.231	0.114	0.459	-0.038
- Median	0.814	0.364	0.692	0.195	0.120	0.541	-0.019
- Minimum	0.053	0.030	0.044	0.008	-1.291	-0.870	-0.970
- Maximum	7.489	3.315	7.446	0.866	0.770	0.897	0.642
- Standard deviation	1.244	0.455	1.188	1.188	0.308	0.341	0.284
<i>Disaggregated series - Non Core</i>							
- Average	4.309	1.347	4.020	0.155	-0.171	0.384	-0.247
- Median	3.226	1.109	2.968	0.094	-0.101	0.437	-0.230
- Minimum	0.003	0.000	0.003	0.008	-2.192	-1.043	-1.590
- Maximum	25.809	6.914	24.991	0.832	0.853	0.862	0.724
- Standard deviation	3.819	1.142	3.725	0.158	0.453	0.347	0.375

The strong relationship between the volatility of inflation and that of its sector specific are also exhibited in table 5.2. The coefficient of correlation between the standard

deviation of inflation and that of sector specific is almost one. This happens to CPI and core and non-core inflation, as shown in tables 5.3 and 5.4.

Sector specific volatility can be interpreted in two ways. First, it is a reflection of structural disturbances. Second, sector specific volatility could also be interpreted as measurement or sampling error in each price sector. To clean up the individual price from this error is difficult. However, the empirical framework adopted here is suitable for this condition, as mentioned in BGM (p.358):

“It is important to note, though, that the empirical framework adopted here is particularly well suited to characterize the effects of aggregate disturbances on disaggregated price series in the presence of measurement error, to the extent that such errors are series specific. In this case, measurement error does generally not distort the estimates of the common components and the estimated effects of aggregate disturbances, even in the extreme situation in which the sector specific components of inflation are entirely driven by measurement error.”

We regress the volatility of the idiosyncratic component on that of the common component and find a positive and robust relationship between the two. The gradient is 2.945, significant at one percent level. The R^2 is also high at 0.71, implying a high goodness of fit. This relationship implies that the sector specific volatility is influenced strongly by the common components that reflect the structural disturbances. Had the volatility of sector specific been mostly influenced by measurement errors, it would have been difficult to find this strong relationship.

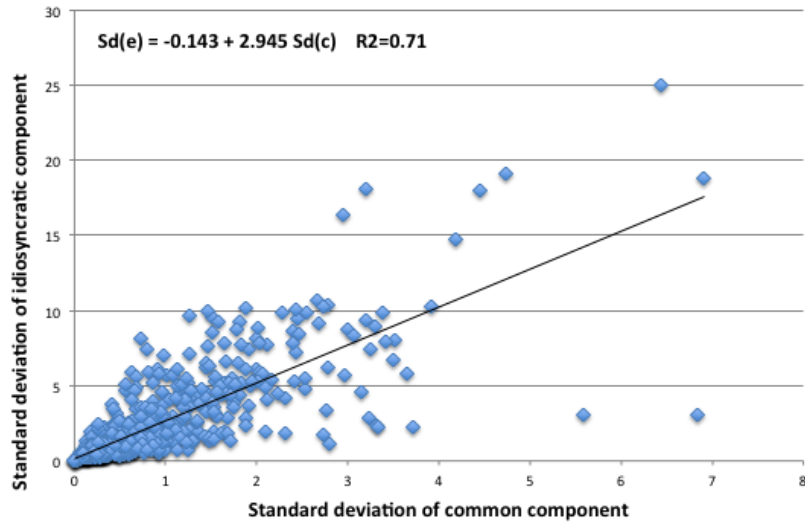


Figure 5.1. Volatility of the Common Component and Idiosyncratic Component

We also compute the inflation persistence using an AR model as in BGM as follows.

$$w_t = \rho(L)w_{t-1} + \varepsilon_t \quad (5.10)$$

where w_t refers to the individual price series, their common component and their specific component. We use 4 lags to be in line with the lags chosen by the information criteria in FAVAR. The degree of persistence is measured here by the sum of the coefficients of all lags. Table 5.1 shows that the inflation persistence of aggregate inflation is higher than for disaggregated inflation. This implies that aggregate inflation is more rigid than disaggregated inflation. At the aggregate level, core inflation is more persistent than non-core inflation, at 0.358 compared to 0.196 and 0.085 respectively. Meanwhile, at a disaggregated level, on average inflation shows almost no persistence.

According to the Calvo models, price stickiness implies a negative relationship between volatility and persistence. This model predicts if the prices are less volatile or stickier, they are less responsive to exogenous shocks. As a result, they become more persistent. Tables 5.2, 5.3, and 5.4 show the coefficients of correlation between inflation

persistence and the standard deviation (as a proxy of volatility of inflation). We find the coefficient is negative for CPI, core, and non-core inflation, as predicted by Calvo models. Even for CPI and non-core inflation, the coefficient correlation is strongly negative: -0.558 and -0.538 respectively. Meanwhile, it is -0.372 for core inflation. This finding is in line with the findings of BGM and does not support the findings of BK.

Table 5.2. Coefficient Correlation for the Volatility and Persistence of CPI Inflation

CPI		Standard deviation			Persistence		
		Inflation	Common component	Sector specific	Inflation	Common component	Sector specific
Standard deviation	Inflation	1	0.840	0.995	-0.558	-0.168	-0.462
	Common component		1	0.785	-0.438	-0.296	-0.364
	Sector specific			1	-0.561	-0.143	-0.465
Persistence	Inflation				1	0.363	0.831
	Common component					1	0.102
	Sector specific						1

According to the Calvo models, price stickiness implies a negative relationship between volatility and persistence. This model predicts that if prices are less volatile or stickier, they are less responsive to exogenous shocks. As a result, they become more persistent. Tables 5.2, 5.3 and 5.4 show the coefficients of correlation between inflation persistence and the standard deviation (as a proxy of volatility of inflation). We find that the coefficient is negative for CPI and core and non-core inflation, as predicted by the Calvo models. Even for CPI and non-core inflation, the coefficient correlation is strongly negative: -0.558 and -0.538 respectively. Meanwhile, it is -0.372 for core inflation. This finding is in line with the findings of BGM and does not support the findings of BK.

Table 5.3. Coefficient Correlation for the Volatility and Persistence of Core Inflation

Core		Standard deviation			Persistence		
		Inflation	Common component	Sector specific	Inflation	Common component	Sector specific
Standard deviation	Inflation	1	0.773	0.990	-0.372	-0.044	-0.244
	Common component		1	0.682	-0.256	-0.206	-0.158
	Sector specific			1	-0.371	-0.005	-0.247
Persistence	Inflation				1	0.493	0.733
	Common component					1	0.137
	Sector specific						1

Table 5.4. Coefficient Correlation for the Volatility & Persistence of Non-Core Inflation

Non Core		Standard deviation			Persistence		
		Inflation	Common component	Sector specific	Inflation	Common component	Sector specific
Standard deviation	Inflation	1	0.800	0.994	-0.538	-0.207	-0.465
	Common component		1	0.735	-0.383	-0.372	-0.340
	Sector specific			1	-0.546	-0.178	-0.471
Persistence	Inflation				1	0.219	0.879
	Common component					1	0.011
	Sector specific						1

If we examine common components and sector specifics, there is also a negative relationship between volatility and persistence. The strength of the relationship is higher for CPI and non-core inflation. If we compare common component and sector specifics, the coefficient correlation is more negative for the latter. This is in contrast to what BGM find based on the US data. They find that the negative correlation is stronger for the common component. Based on their findings, BGM argue that this makes the Calvo models more successful in describing volatility and persistence inflation in response to macroeconomic shocks rather than sector specific shocks. Meanwhile, in our case, the

Calvo models seem suitable for explaining the volatility and persistence of Indonesian inflation, but might be more suitable for explaining the volatility and inflation persistence in response to sector specific shocks. Further research is needed to address this issue.

5.5.2. Impulse Responses of Prices to Macroeconomic and Sector Specific Shocks

We construct an AR model of the two components of inflation: the common component ($\lambda'_t C_t$) and the sector specific component (e_{it}). We use 4 lags in order to be consistent with the lags of the FAVAR framework in this exercise. We impose shocks of minus one standard deviation, and observe the impulse responses of disaggregated prices in terms of their common and sector specific components. We interpret these as the impulse responses of disaggregated prices to the macroeconomic and idiosyncratic shocks.

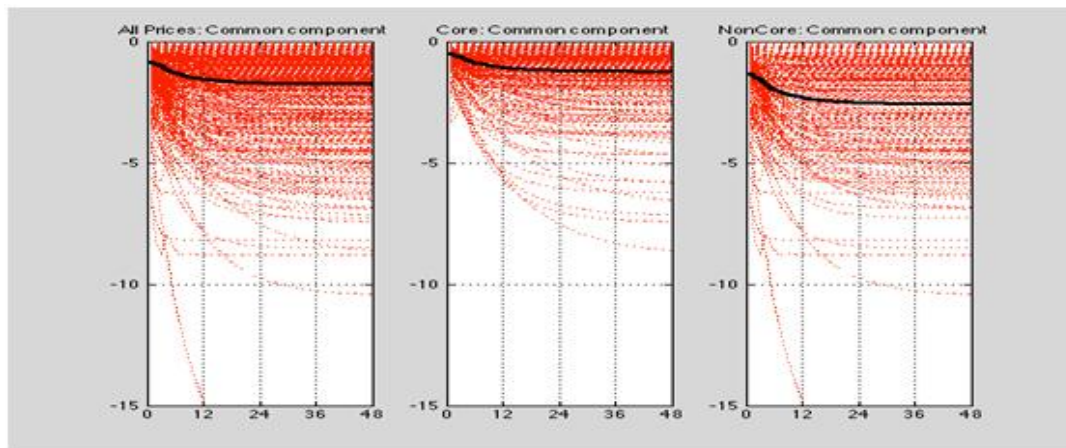


Figure 5.2. Impulse Responses of Prices to Macroeconomic Shocks

Figure 5.2 shows the impulse responses of prices (in percent) to macroeconomic shocks, measured by a minus one standard deviation shock to its common component. The figures consist of three panels: the first panel shows the responses of all disaggregated prices, the second panel the responses of disaggregated core prices and the third panel the responses of disaggregated non-core prices. The red curves are the impulse responses of

disaggregated prices and the solid black curve is the average of the impulse responses. Here, the weight of each price is equal, and is not based on the actual expenditure weights.

The panels show the heterogeneity of price behaviour, given a macroeconomic shock. The magnitudes and the periods of responses are different across prices. The average impulse responses show that most of the prices fall moderately in the first few months and continue to fall slowly until they reach their new equilibrium. The speeds of adjustment also exhibit heterogeneity. Some prices reach their new equilibrium in less than 12 months, while others need more than 12 months to reach this. Comparing the core and non-core prices, the core ones are less responsive than the non-core. On average, the magnitudes of the impulse responses of core prices are less than those of non-core prices. The speed of adjustment of non-core prices is also more heterogeneous.

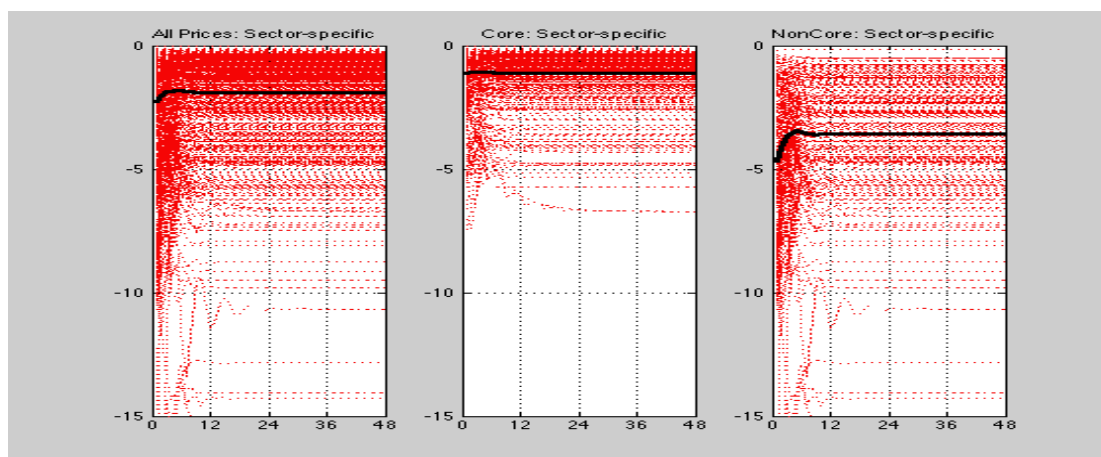


Figure 5.3. Impulse Responses of Prices to Sector Specific Shocks

Figure 5.3 shows the impulse responses of disaggregated prices (in percent) to sector specific shocks. Unlike the previous figure, this figure shows the immediate responses of disaggregated prices to the sector specific shocks, with prices falling immediately to their new equilibrium in the first few months after the shocks. The impulse responses also exhibit heterogeneity among the prices. Some prices deviate by less than five percent, while others deviate more than five percent from their initial level. As in the

previous figure, the non-core prices are also more responsive. The magnitude of their impulse responses to sector specific shocks is on average higher than that for the core prices.

A comparison between figures 5.2 and 5.3 illuminates the difference in the speed of adjustment of prices to different types of shocks, with this speed reflecting how flexible the prices are. Both macroeconomic and sector specific shocks affect disaggregated prices immediately. On average, disaggregated prices are more flexible in the face of sector specific shocks, as the new equilibrium of prices is reached immediately. The magnitudes of impulse responses are also greater. In contrast, disaggregated prices respond more sluggishly to macroeconomic shocks, still responding gradually after the macroeconomic shocks for several periods until approaching their new equilibria. The differences show that the source of shocks matters.

This finding is also found in BGM. Prices in the US are sluggish in response to macroeconomic disturbances. We provide the impulse responses in the case of the US in Appendix 5.4. The difference from the Indonesia data is that there are a greater number of prices that are more flexible to macroeconomic disturbances. Figure 5.1 shows that the disaggregated prices fall immediately in the first few months. After that, the prices are sluggish as the impulse responses move slowly. In general, prices in Indonesia are more flexible than in the US in response to macroeconomic shocks. One possible explanation for this is that Indonesia as a small open economy is more exposed to fluctuations in the world economy than the US. The trade ratio of Indonesia, measured by the sum of exports and imports to GDP, is higher than for the US in the period of estimation. Its exchange rate also fluctuates following the dynamics of the world economy. Meanwhile, since January 1985, the nominal effective exchange rate of the USD has displayed low volatility. The

higher volatility of the rupiah, a macroeconomic variable, may be reflected in prices that are also more flexible, given the exchange rate pass through to prices.

5.5.3. Impulse Responses of Prices to Policy Rate Shocks

In the previous sections, we have compared the volatility and persistence of disaggregated prices and evaluated the impulse responses of disaggregated prices to sector specific and macroeconomic shocks. Macroeconomic shocks represent disturbances that happen to a group of macroeconomic variables. These involve a shock to a macroeconomic variable such as the exchange rate or interest rate. Hence the impulse responses generated are not caused by a specific shock such as a change in the policy interest rate. We cannot disentangle macroeconomic shocks into a set of specific shocks.

Here, we need to know the behaviour of prices given a specific shock, in particular monetary policy shocks, to observe the role of monetary policy. In order to do this, we impose a shock on the observable variable (R_t) in equations (5.7) and (5.8). We use policy rate as a proxy for monetary policy and identify the monetary policy shock by assuming that policy rates respond contemporaneously to a shock to the latent factors (F_t). In contrast, the latent factors can respond to an unanticipated policy rate shock after a month. There is a lag between an unanticipated policy rate shock and the response of the latent factors. The FAVAR framework then allows us to examine the impulse response of disaggregated prices to an unanticipated policy rate shock.

This unanticipated shock is a 25 basis point policy rate increase, which imposes monetary policy contraction. Theoretically, the inflation rate should decrease following monetary contraction. However, we find different results. Figure 5.4 shows the impulse responses of disaggregated prices (in percent) for all prices, core and non-core.

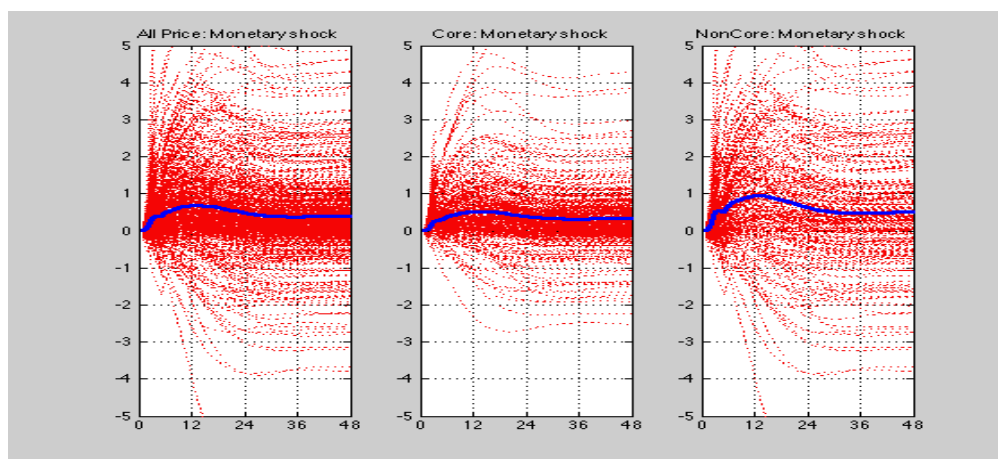


Figure 5.4. Impulse Responses of Prices to Policy Rate Shocks

We again find heterogeneity of the responses, not only in terms of magnitude and speed of adjustment, but also in direction. Some prices decrease, but others increase. If we give an equal weight to each individual price, on average the responses increase slightly. If we compare the responses of core and non-core prices, we find that the core prices are less responsive. Compared to what BGM found based on the US data (see Appendix 5.4), the impulse responses are similar. Some prices decrease following monetary policy contraction. The difference is that in BGM the average of impulse responses is negative for the US data, while we find, on average, slightly positive impulse responses for the Indonesian data. In other words, Indonesia displays a greater price puzzle. In addition, this puzzle is persistent; the average impulse responses do not decrease in the long run.

There are some possible explanations for the price puzzle. From a modelling perspective, Sims (1992) suggests that misspecification in VAR models, in particular the omission variable problem, is the cause. Comparing OECD countries, he finds that France and Japan experience a price puzzle, and that this positive relationship between monetary policy shock (contraction) and price is significant and persistent. One possible explanation is that the policy makers have anticipated the future inflation and consequently contract the monetary policy variable. As predicted, prices increase, though less than if the policy rate

had not been raised. This anticipated inflation is not accommodated in the model, so generates a price puzzle. Furthermore, a policy rate increase may signal to firms that inflation would otherwise rise more than the firms had anticipated. And if price adjustment costs are convex (as in Rotemberg, 1982), firms may already have embarked on a gradual sequence of price increases, from which deflation will take time.

Christiano, Eichenbaum and Evans (1994, 1996), henceforth CEE, propose that commodity prices be included in VAR models. These prices can capture future inflation and supply shocks and therefore the omission problem can be avoided. The order is output, aggregate price, commodity price and policy rate. This can solve the puzzle for the full sample of 1960-1990 US data. Balke and Emery (1994) replicate the VAR model of CEE (1994) but with a different period. They demonstrate that the puzzle is not resolved before the 1980s and test other variables to solve the puzzle. One variable that can solve it is the spread of short and long-term interest rates. Including this variable can solve the puzzle in the pre-1980s.

When the FAVAR technique is applied, the omission problem should be avoided or the possibility of its presence should be reduced, as many variables are included. Hence, there could be other explanations for this puzzle.

Theoretically, there are two main effects of monetary policy on the economy: demand side effects and supply side effects. The study of the monetary policy transmission mechanism is mostly related to the former. There are various channels already studied which relate to the demand effect: the interest rate channel, the exchange rate channel, the expectation channel, the credit channel (bank lending and balance sheet) and the asset price channel. Generally, the research concludes that monetary contraction will reduce aggregate demand and that the economy will end up with lower price levels. The supply

side views support the notion that the effect of monetary changes will affect the cost of production, hence it is also called the cost-side effect. Unlike the demand effect, which shifts aggregate demand, the cost-side effect shifts aggregate supply. In the case of monetary contraction, both aggregate demand and aggregate supply will shift to the left. Whether the price will be higher or lower depends on the dominance of one of these two effects. The price puzzle that occurred in our case may not have been because of misspecification problems, but because of the economic conditions in Indonesia during the estimation period. This may explain the dominance of supply side effects.

There are some possible explanations for such supply side effects. Interest rate increases may raise the cost of production through tightened credit conditions. For instance, firms face costs such as wage payments, which they incur before selling their products. As they finance these costs through credit, tight monetary policy worsens their credit condition. As a result, the firms reduce their labour demand and hence their production. Moreover, the monetary contraction may exacerbate the supply side effect through a reduction in demand. The firms may face internal financing difficulties as fewer products are sold or there are increasing inventory costs and account receivables, so turn to external financing (Barth and Ramey, 2001). Both direct and indirect effects compel the firms to increase the price of their products. Another explanation is market concentration. When demand decreases as a result of monetary contraction, many firms may exit the market. The fewer firms who stay in the market may enjoy increased oligopoly power and raise their prices.

From the impulse response above we notice that not all price series exhibit a puzzle. Many prices also decrease following monetary contraction. This heterogeneity suggests that different effects work dominantly on different prices. In the subsequent

sections, we elaborate on some estimates to establish whether the puzzle in terms of aggregate prices diminishes or even disappears.

5.5.4. Impulse Responses of Prices to Deposit and Loan Rate Shocks

Regarding monetary policy shock, we have used the policy rate as the proxy of monetary policy. We imposed the shock on the policy rate to picture the monetary policy contraction. We now try other observable variables: the three month deposit rate and working capital loan rate. The deposit rate and loan rate are two representatives of market rates, which are closer to the real sector. Generally, the changes in policy rate should be transmitted to these retail rates.

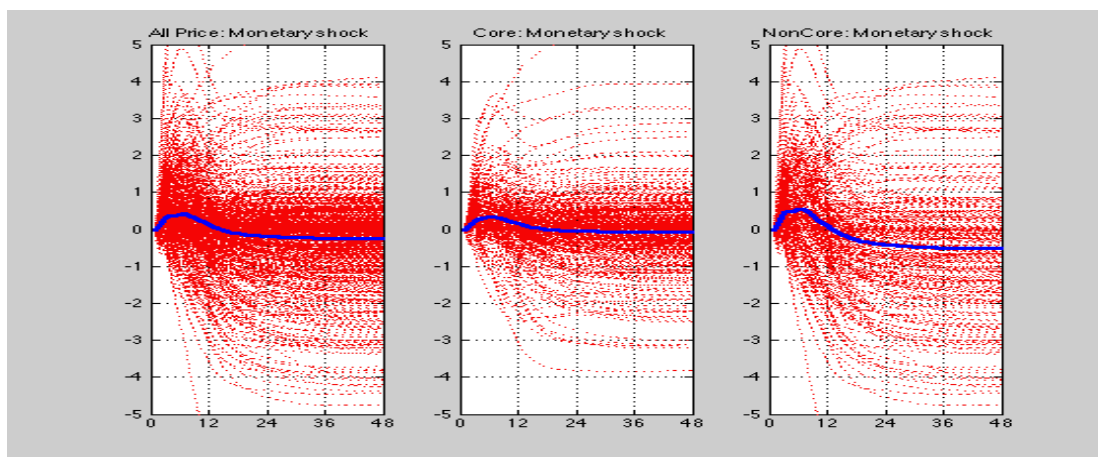


Figure 5.5. Impulse Responses of Prices to Deposit Rate Shocks

We impose a 25 bps increase on the deposit and the loan rates, which reflects monetary policy contraction. The pictures are similar in terms of heterogeneity, as shown in figures 5.4, 5.5 and 5.6. Some prices rise following the increase in the deposit or loan rate while others fall. However, in terms of average prices, the pictures are quite different. In the two last figures, the impulse responses show that prices rise after the increase in the deposit and loan rates, up to twelve months later. After that, on average, prices fall. This means that after twelve months more prices fall following the increase in deposit and loan rates. The puzzle is no longer persistent.

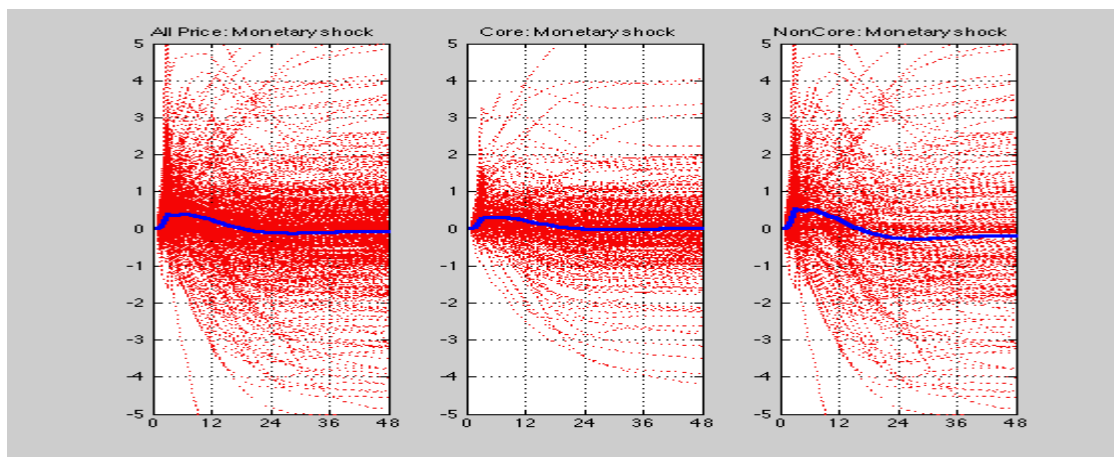


Figure 5.6. Impulse Responses of Prices to Loan Rate Shocks

Up to this point, we can see different pictures given different proxies of monetary policy. The closer the proxy to the market rate, the more the puzzle tends to be reduced. The increase in deposit and loan rates has more impact on the fall in prices than the impact of a policy rate increase.

5.5.5. Relationship Between Policy Rate and Market Interest Rate

The impulse responses show that market rates have a greater influence on prices. Hence, it is better to use one of these market rates as an observable variable in order to examine the effect of the change in interest rate on prices. This raises the question of whether the deposit rate or the loan rate has a closer relationship with the policy rate. In this section examine this relationship.

We follow Heffernan (1997) and Sinclair (2005) in analysing these relationships, using an error correction model (hereafter ECM). Heffernan evaluates these relationships for some UK market interest rates and Sinclair for a number of countries. Heffernan notes that there are reasons why the market interest rate displays sluggishness in responding to changes in the policy rate. First, when the policy rate changes, each bank will guess the reaction of the other banks, making slow adjustments to a new equilibrium. Second, banks may face sunk cost and menu cost. Third, bank consumers lack information, or face

switching costs if they move to a different bank. Banks exploit this inertia by not changing interest rates as frequently as policy rate changes. Fourth, banks take time to decide whether changing their interest rate is more profitable or not. This argument is based on the Stiglitz Weiss (1981) model, which shows that increasing the loan rate may increase defaults.

Although we cannot distinguish which factors influence the sluggishness using the ECM model, at least we can quantify this by looking at the short and long run coefficients. We employ the ARDL cointegration approach of Pesaran, Shin and Smith (2001), henceforth PSS, to provide us with an ECM model. This approach is suitable for a single equation model and is superior to the Engle and Granger (1987) two-step approach in the case of a small sample. In addition, ARDL cointegration is applicable regardless of whether the series are $I(0)$ or $I(1)$. According to the ADF unit root tests, it is not clear whether the series are stationary or not, even though the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test confirms that all the interest rate series are non-stationary (See Appendix 5.5 for the unit root test results of these interest rates). In this situation, the ARDL cointegration approach with its *bound test* again provides an ideal solution. The explanation for this approach is provided in chapter 2 (pages 49-51). For the purpose of comparison, we also perform the cointegration test using the Engle-Granger approach.

We estimate the model for the full sample period and then for two sub-sample periods before and after implementation of the Inflation Targeting Framework (ITF) in Indonesia. After the Bank Indonesia Act of 1999, the monetary policy objective became price stability. Implicitly, the transition to ITF had already begun and preparations to implement the framework in full were pursued. In July 2005 Bank Indonesia formally adopted ITF and used the policy rate as the monetary instrument. This regime change

should have altered the influence of the central bank rate on the other market rates. Before July 2005, the central bank policy rate was the rate of the one month Bank Indonesia certificate; after that, it was the Bank Indonesia policy rate. The movement of these two interest rates were in line and we call both interest rates the policy rate.

Table 5.5. Cointegration Tests Between Policy Rate and Market Interest Rate

	ARDL-PSS						Engle-Granger					
	Full Period		Pre IT		Post IT		Full Period		Pre IT		Post IT	
Deposit Rate	5.54	*	10.36	**	2.56		-2.85	*	-2.70	*	-3.09	**
Loan Rate	5.88	*	24.80	**	2.17		-2.66	*	-0.91		-2.52	

***, **, * reject null hypothesis there is no cointegration at significance level 1%, 5%, 10% respectively
The test are based on Wald test for ARDL-PSS and ADF test of the residual for Engle-Granger

The ARDL-PSS approach shows that the cointegration between the policy rate and both the deposit and the loan rates is significant except for the period after the ITF. The F statistics show that cointegration before the ITF is more significant than in the full period. For a comparison, the Engel Granger approach shows that cointegration is also not significant in the period before the ITF for the loan rate.

There are some explanations for failed or weak cointegration, as noted by Heffernan (1997). One possible explanation is the change of competitive cycle. Previously, before the ITF, the rates were more competitive and responded immediately with high elasticity. Later, competition may not have been so tight, so this might have made the market rates less sensitive to a policy rate change. Another explanation is the presence of the opportunity cost, in particular during the peaks and troughs of the interest rate cycle. Banks may be more reluctant to change their interest rates at these peaks and troughs because they might think their customers respond less to changes than during the transition periods between them. After the ITF, there were more peaks and troughs. Another possible

explanation is that the market interest rate was more regulated before the ITF. This might have been a driving force to make these rates follow the monetary policy rate.

We estimate the error correction model of the deposit and loan rates with the policy rate as the regressor if we find that the cointegration is significant. From these ECM models we observe the long run relationship between the policy rate and deposit and loan rate by looking at the coefficient in the long run part. For the short run behaviour, we see the coefficient of the speed of adjustment.

Table 5.6. Long Run Coefficients of the Market Interest Rate

	ARDL-PSS					Engle-Granger				
	Full Period		Pre IT		Post IT	Full Period		Pre IT		Post IT
Deposit Rate	0.97	***	1.17	***	NA	0.97	***	1.20	***	0.74 ***
Loan Rate	0.99	***	0.75	***	NA	0.66	***	NA		NA

***, **, * significance level at 1%, 5%, 10% respectively . NA: Not Applicable

The coefficients of the policy rate in the deposit and loan rate model are significant. In the full period, the influence of the policy rate on the loan and deposit rates is similar. However, in the period before the ITF, the relationship between the policy and deposit rates is much stronger.

Table 5.7. Speed of Adjustment

	ARDL-PSS					Engle-Granger				
	Full Period		Pre IT		Post IT	Full Period		Pre IT		Post IT
Deposit Rate	-0.04	***	-0.11	***	NA	-0.04	***	-0.12	***	-0.04 **
Loan Rate	-0.04	***	-0.11	***	NA	-0.04	***	NA		NA

***, **, * significance level at 1%, 5%, 10% respectively . NA: Not Applicable

The sign of the coefficient of speed of adjustment is also significant and as expected in all periods. From the magnitudes, the coefficients are smaller in the full period sample. This implies that only 4 percent of the deposit and loan rates are corrected in one month. On the other hand, this figure is more than 10 percent in the period before the ITF.

This also supports the cointegration test in the ARDL-PSS approach, that the long run level relationship is more significant before the implementation of ITF. These relatively higher coefficients imply that the long run part of these models has a stronger influence.

In conclusion, the long run link between the policy and deposit rate is stronger than the loan rate to policy rate link. This is clearly shown in the long run coefficient of the policy rate before the ITF, which reflects that the elasticity of the deposit rate is higher. This implies that the deposit rate is more sensitive to the policy rate, so the loan rate is more sluggish. A possible explanation for this is that after the Asian crisis banks in Indonesia tried to keep their non-performing loans (NPL) low. This made the banks more reluctant to increase their loan rates. Most borrowers also faced solvency problems after the crisis, which could have made them more sensitive to loan rate changes. In order to keep their customers, banks prefer not to increase their loan rates following monetary policy contraction. In addition to this, the stronger relationship between the policy and deposit rate is also supported by the cointegration test results, in particular the Engle-Granger approach. The estimation results show there are more cointegration relationships between the deposit and policy rates in all the sample periods. Given these results, in the subsequent analysis we use the deposit rate as the observable variable. With the close relationship between the policy and deposit rates, we examine the effect of the change in interest rate on prices.

5.5.6. Impulse Responses of Prices: Pre and Post Inflation Targeting

In the previous sections we have observed the varying impact of monetary contraction on prices. Some prices demonstrate a price puzzle, while others do not. We also observe the relationship between the policy rate and the market interest rate before and after the implementation of ITF. We come to the conclusion that in general the

relationship between these two rates is stronger than that between the policy rate and the loan rate. Given this, we shall investigate what the impact of monetary contraction, represented by an increase in the deposit rate, is on prices; in particular, whether the impact is stronger or weaker after the implementation of the ITF.

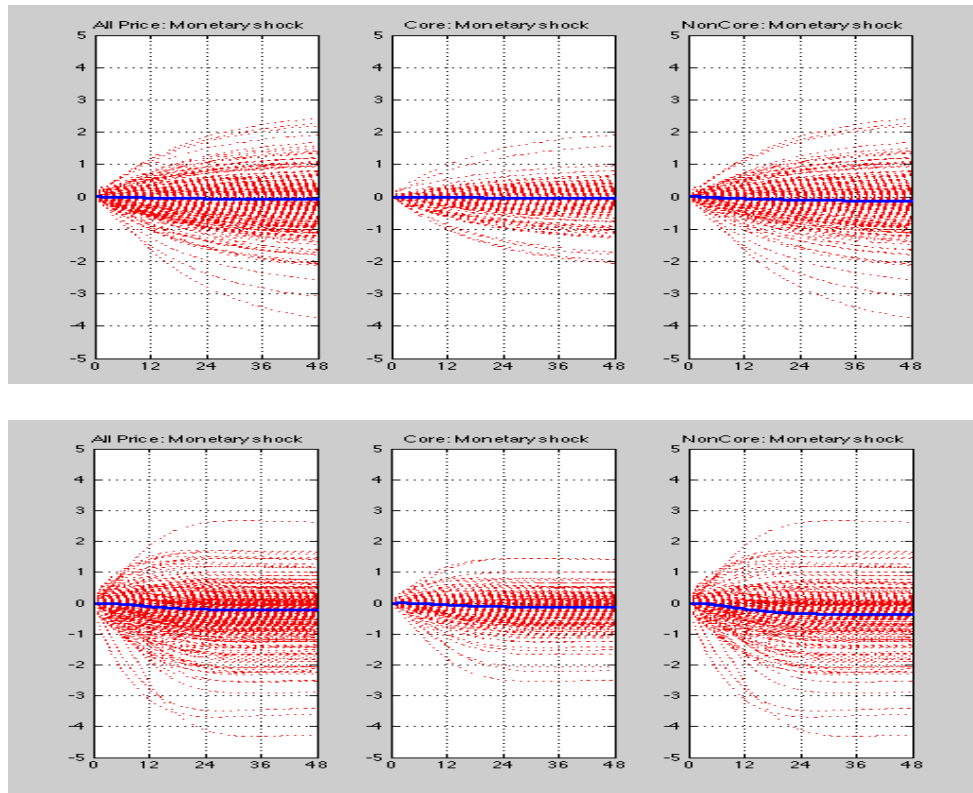


Figure 5.7. Impulse Responses of Prices to Deposit Rate Shocks: Pre (upper) and Post (lower) ITF

For the period after the ITF, we obtain five factors to represent the data based on Bai and Ng's (2002) approach. We apply one lag, based on the Schwarz information criterion (SC). Even though some information criteria suggest two lags, we choose one. If using more than one lag, the impulse responses are more volatile, given the limited number of observations. For the period before July 2005, we use two factors and one lag based on the same procedure and reasoning. We find the impact of the changes in deposit rate is stronger after the implementation of ITF, as shown in the lower panels of figure 5.7. On average, prices decrease after 12 months. In contrast, before the ITF is implemented

formally, the average of prices is more inert after a monetary contraction. Comparing the groups of prices, on average non-core prices decrease more than core ones.

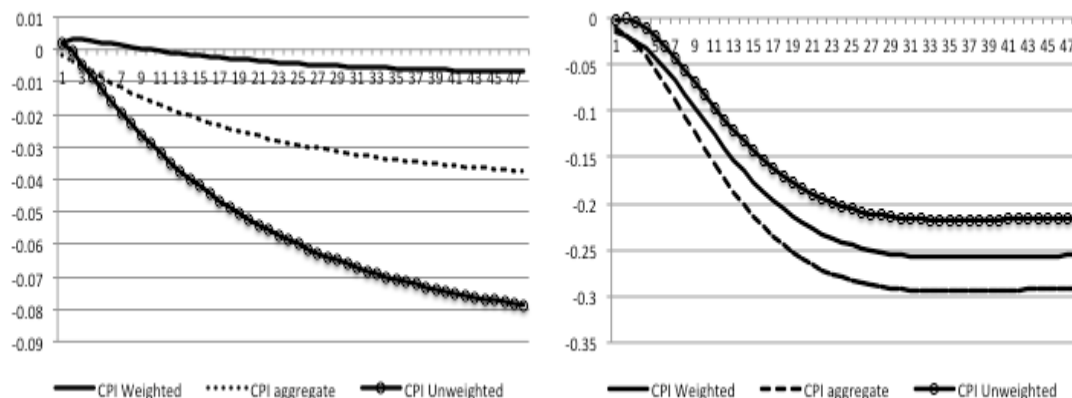


Figure 5.8. Impulse Responses of CPI: Pre (left) and Post (right) ITF

If we examine the comparisons across the aggregate CPI, the unweighted average and the weighted CPI as shown in the right panel of figure 5.8, the price puzzle disappears in the period of ITF for all CPI definitions. Before full implementation, the weighted CPI still exhibits the puzzle. Moreover, the impact of interest rates on CPI is more apparent after the implementation of ITF. CPI decreases significantly for up to 24 months following the deposit rate increase and reaches its new long run equilibrium after that. Meanwhile, the decrease in CPI before the ITF is not as marked as in the ITF period.

A possible explanation is revealed by Castelnuovo and Surico (2010). Using a VAR model, they find a price puzzle before the Paul Volcker era (pre-1979) for the US data. They support the argument that price puzzles typically emerge in the sub sample associated with weak central bank responses to inflationary pressure. During a weak monetary policy response, inflation expectations are remarkably high. This is not captured by a VAR model and creates a price puzzle.

In our case, before the ITF, monetary policy was eclectic, in the sense that the instruments used varied, such as base money and interest rates. The mixed monetary instruments make the signal unclear. One instrument may generate monetary contraction, while another may result in expansion. In contrast, after the ITF the economic agents may have accepted the interest rate as the main instrument of monetary policy. The stance of monetary policy is clearer, the monetary transmission of the interest rate is stronger, and as a result the effects on prices are more marked during the ITF period.

The absence of a price puzzle also suggests that the supply side effects become weaker after ITF implementation. In the more recent period, financial institutions have been more innovative and developed. This results in more alternative sources of funds, so monetary contraction has less influence through the cost channel. Even though credit will shrink after monetary contraction, firms may have more access to sources of finance other than credit. Another possible explanation is that the influence of the interest rate on exchange rates strengthens. As the interest rate increases, the exchange rate appreciates more significantly. As a result, imported material becomes much cheaper, which helps counterbalance the interest cost faced by firms. Overall, the supply side effect is weaker and the demand effect is dominant and leads to lower prices. This is also US evidence that the transmission of the cost channel was weaker after the Volcker era (Barth and Ramey, 2001).

5.5.7. Impulse Responses of Disaggregated Prices and Some Macroeconomic variables to Monetary Policy Shock: Post Inflation Targeting

As previously noticed in figure 5.8, there are differences between the impulse responses of aggregate and disaggregated prices in both pre- and post ITF. The different magnitude of the impulse responses between the aggregate prices and the average of

unweighted disaggregated prices demonstrates the importance of weighting. Moreover, the aggregate CPI consists of all CPI prices, while the disaggregated prices cover 96 percent of CPI prices. In this section we shall examine the difference between these impulse responses. We shall also focus on the post ITF period, when the change in interest rate, in particular the deposit rate, had more impact on prices. This period is more relevant to policy makers as ITF was already fully implemented. Furthermore, as previously shown, the price puzzle also disappears in this period. In this way, we also avoid the risk of misspecification problems.

From table 5.8 we can see, in terms of aggregate prices, that the CPI decreases by 0.173 percent after 12 months. Subsequently, it is -0.28 percent and -0.291 percent after 24 and 48 months respectively. Meanwhile, the unweighted average prices of disaggregated CPI decreases by 0.109 percent after 12 months, while after 24 and 48 months, the impulse responses are -0.203 percent and -0.216 percent.

The aggregate for core prices still exhibits a puzzle up to the 6th month. The aggregate for core prices falls 0.025 percent after the 12 months. After 24 and 48 months, it decreases by 0.066 percent and 0.073 percent respectively. Compared to the CPI, the responses are weaker. In both aggregated and disaggregated prices, the impulse responses of non-core prices are stronger than those for core prices.

Table 5.8. Price Responses: Post ITF

	Price responses (in percent)			
	6 months	12 months	24 months	48 months
<i>Aggregated prices</i>				
CPI	-0.072	-0.173	-0.280	-0.291
Core	0.002	-0.025	-0.066	-0.073
Vol. Food	-0.102	-0.207	-0.301	-0.306
Adm. Prices	-0.273	-0.597	-0.921	-0.950

	Price responses (in percent)			
	6 months	12 months	24 months	48 months
<i>Disaggregated prices - CPI</i>				
- Average	-0.031	-0.109	-0.203	-0.216
- Median	-0.006	-0.039	-0.080	-0.086
- Minimum	-2.119	-3.118	-4.115	-4.268
- Maximum	1.066	1.848	2.605	2.629
- Standard deviation	0.268	0.457	0.618	0.623
<i>Disaggregated prices - Core</i>				
- Average	-0.010	-0.056	-0.117	-0.126
- Median	-0.003	-0.024	-0.048	-0.052
- Minimum	-0.960	-1.810	-2.488	-2.498
- Maximum	0.730	1.176	1.446	1.428
- Standard deviation	0.160	0.283	0.388	0.392
<i>Disaggregated prices - Non Core</i>				
- Average	-0.063	-0.193	-0.339	-0.356
- Median	-0.017	-0.086	-0.191	-0.197
- Minimum	-2.119	-3.118	-4.115	-4.268
- Maximum	1.066	1.848	2.605	2.629
- Standard deviation	0.378	0.634	0.634	0.852

Some other macroeconomic variables also change. The nominal exchange rate appreciates following the increase in the deposit rate. The increase of 25 basis points in the deposit rate appreciates the nominal exchange rate by as much as 0.5 percent after 18 months. Broad money also decreases following the monetary contraction, although not significantly. Unlike the CPI, which is rigid or only reacts after two months, the components of GDP react immediately after the changes in monetary policy. Total consumption decreases by up to 0.4 percent from its initial level. This is also significant (within a 90 percent confidence interval) for up to 24 months. The 25 bps contraction also significantly affects investment, exports and imports. Exports fall by as much as 0.6 percent after the twelfth month from their initial level following the appreciation of the exchange rate, while total investment also decreases significantly by around 0.4 percent at the twelfth month and subsequently. Imports also fall because of the decrease in domestic

demand, despite the exchange rate appreciation. However, this combination makes real GDP fall only slightly, and is not significant. In line with GDP, the production index as a proxy of the production sector also slightly decreases, but not significantly.

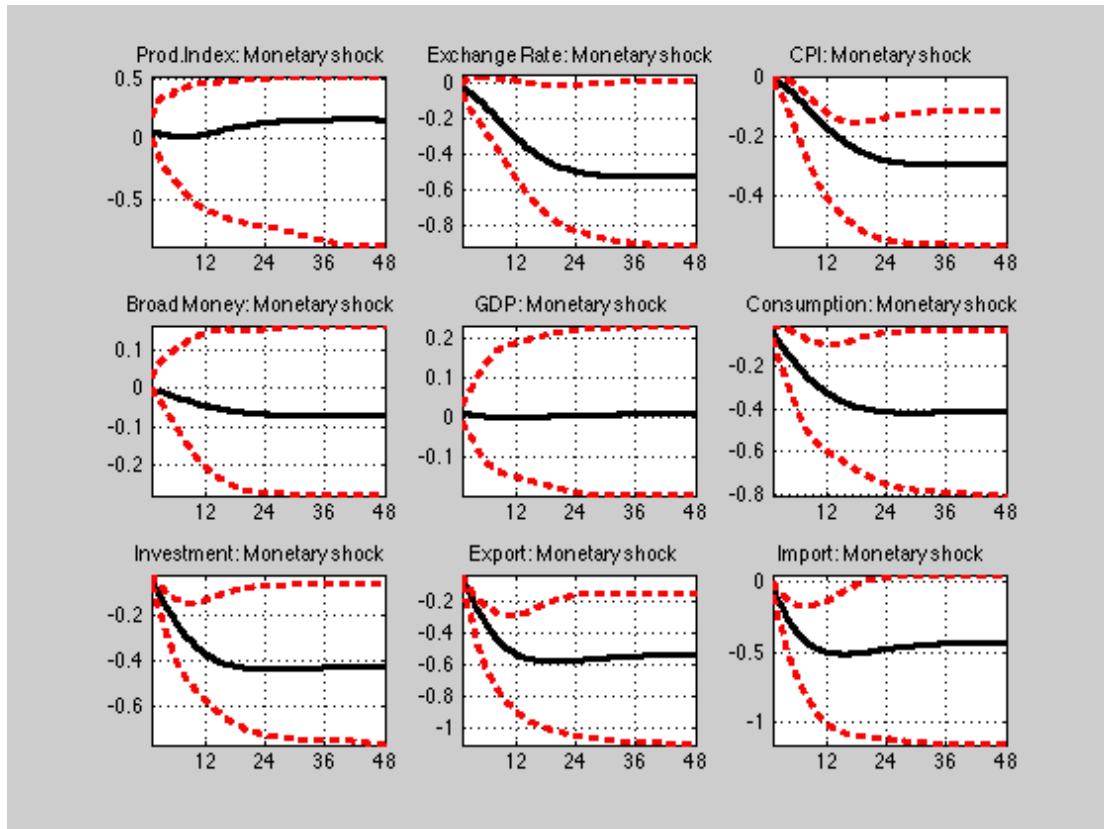


Figure 5.9. Impulse Responses of Some Macroeconomic Variables

A combination of significant price decreases and relatively stable output may reflect greater price flexibility (or a steeper aggregate supply curve). From the impulse responses of prices to macroeconomic shocks and specific sector (figures 5.2 and 5.3), greater price flexibility is also confirmed as prices react immediately after the shocks, even macroeconomic ones. The persistence of inflation, both aggregated and disaggregated, is also relatively small, at less than 0.5, compared to what is found in the US data (BGM, 2009).

5.5.8. The Impulse Responses of Specific Group of Prices To Monetary Policy

Shock: Post Inflation Targeting

The previous results demonstrate the heterogeneity of price responses to monetary shocks. In order to examine this heterogeneity, we shall examine which groups of prices increase or decrease following monetary contraction. As in the previous section, we shall focus on the period after the implementation of ITF for the same reasons.

We aggregate the impulse responses based on specific groups of core and non-core prices using the 2007 weight as the base. We divide core prices into seven groups: food and beverages (16.3), housing (19.1), clothing (6.95), health (4.37), education (4.45), entertainment (2.62) and transportation, communication and financial services (9.8). Meanwhile, we divide non-core prices into two groups: food and beverages (19.62) and others (12.87). The values in brackets are index weights.

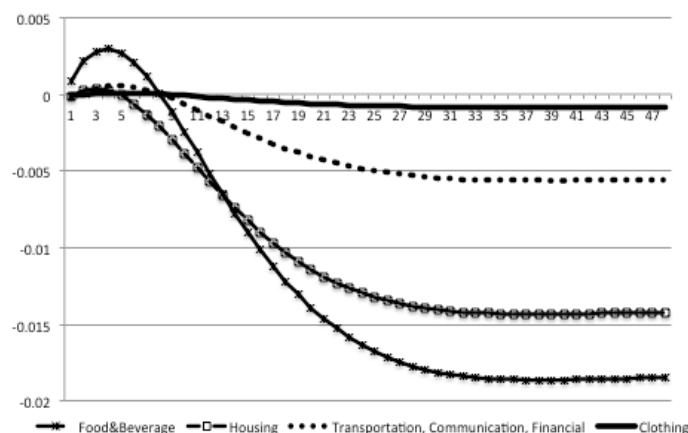


Figure 5.10. Impulse Responses of Core Price Groups

Figure 5.10 shows the impulse responses of four groups of prices in the core price group. On average, this set of prices falls after an increase in the deposit rate. These prices account for 52 percent of CPI. The puzzle still appears, in particular in food and beverage prices. These prices also respond more, falling by more than 0.015 percent after 24 months. On the other hand, clothing prices are steady.

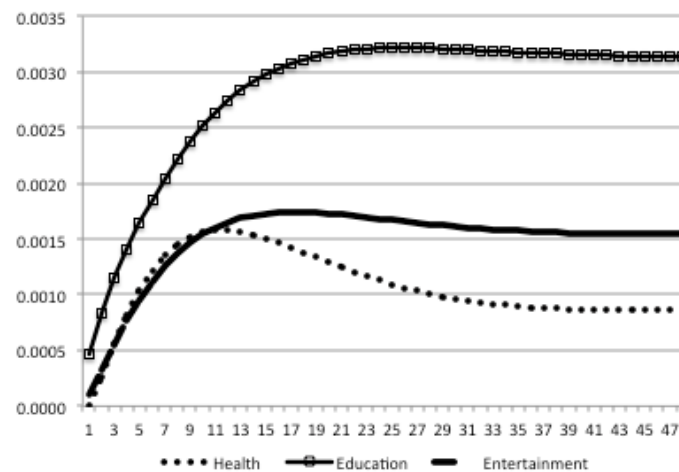


Figure 5.11. Impulse Response of Core Price Groups (continued)

Three other groups of prices rise following monetary contraction, as shown in figure 5.11. Those are the health, education and entertainment groups of prices, which account for 11.4 percent of CPI. The impulse responses are smaller than for the former group; this hints at the dominance of the cost channel in this case. If we observe the items in these groups, the producers are most likely to face enhanced credit-financing costs. These items include costs for hospital care, medicine, school and course tuition fees, and entertainment products such as music equipment and cinema. One might think that most of the firms involved in price setting in these groups are large ones, with more access to bank loans and hence more dependent on bank financing. These firms optimise the present value of their future prices in consideration of the interest rate. As the market interest rate increases, so does the interest cost. As a result, these firms set their prices higher. Another explanation is that there may be many small firms which supply parts to those larger ones. These small firms are more sensitive to fluctuations in the loan rate. As a result, these producers cover the increase in interest costs by increasing their prices, although there is an exception if the service is a commitment. So the servicing cost is a fixed cost as far as the borrowing firm is concerned. In this case, a profit-maximising firm does not raise prices if

fixed costs change. This cost channel is more obvious if we use the loan rate as the observable variable. The magnitudes of the impulse responses are more positive for the three groups of prices above, which shows that if there is an increase in unanticipated shocks on loan rates, the prices in these groups will also rise. The impulse responses where the loan rate is the observable variable are provided in Appendix 5.7. Another possible explanation is the price setting in these groups of prices follows Rotemberg (1982). For example, the firms in these three sectors, which are non-traded, respond to the shocks by increasing their prices gradually given the price adjustment is convex. Suppose there is an exchange rate depreciation that makes policy maker reacts by increasing policy rate. As the firms have already embarked on a gradual sequence of price increase, it takes more time to see the effect of policy rate increase.

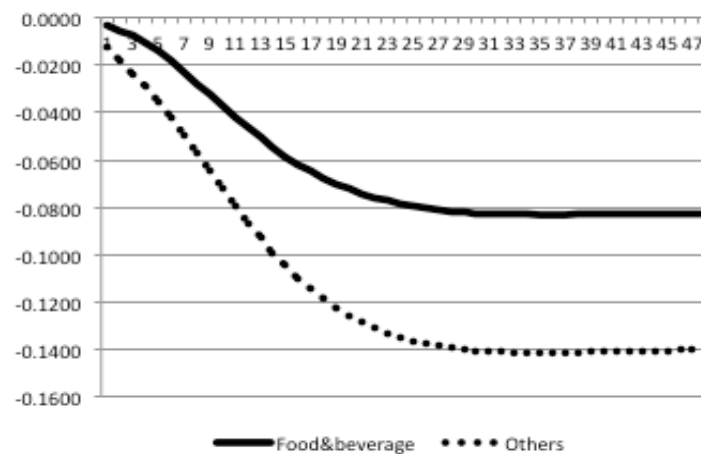


Figure 5.12. Impulse Responses of Non-Core Price Groups

As previously mentioned, the impulse responses of non-core prices are stronger than for core prices. If we observe figure 5.12, both groups of non-core prices exhibit falls and there is no price puzzle. The magnitudes are also bigger. Food and beverage prices, which account for 19.62 percent of the CPI, fall by up to 0.08 percent in the non-core prices compared to the core ones, which is no more than 0.02 percent. Others prices fall even more, by -0.14 percent at and after the 24th month.

Assuming that the deposit rate strongly influences aggregate demand in the economy, the above figures demonstrate that prices in the housing sectors, food sectors and all non-core prices are sensitive to demand factors. On the other hand, prices in health, education and entertainment are more sensitive to cost factors. As interest rates increase, the costs of production in these sectors also increase and hence prices rise.

The larger group of prices falls following interest rate increases. As these prices have more weight, the CPI as aggregate also decreases. It can be seen in figure 5.8 that all the CPI, the unweighted, the weighted and the aggregate decline with similar path.

5.6. Conclusions and Policy Implications

The effect of monetary policy, which involves changes in policy rate, on inflation is not immediate and displays distributed lags. A major challenge is to identify the speed with which policy rate affects inflation as well as other macroeconomic variables. It is therefore crucial to investigate the lag structure for inflation following policy rate changes. Furthermore, many econometricians have discovered that the movement of inflation is perverse after the policy rate changes. They usually use a broad measurement index such as CPI to examine the dynamic of inflation. Understanding the forces behind the lag and the initial perverse effect is greatly assisted by scrutinising the dynamics of individual components of this index. By that, we can have a better understanding how prices respond differently across sectors to monetary policy changes.

This chapter scrutinises the inflation dynamics in Indonesia using disaggregated CPI data. The analysis of disaggregated data complements the studies of inflation dynamics using aggregate data in the previous chapters. We use FAVAR, as in BGM. This technique allows us to analyse both aggregate and disaggregated prices with the same framework simultaneously. By employing disaggregated data, we deal with the

combination of a large number of data with a limited number of observations. FAVAR provides a solution for this condition. Various conclusions can be derived from these estimation results.

The main finding of this analysis is that price behaviour in Indonesia exhibits heterogeneity. We can see this from the impulse response of each price to a shock. It is evident not only in terms of the magnitude, but also in the direction and the speed of adjustment to the new equilibrium. This heterogeneity becomes clearer when we examine the behaviour of groups of prices in the period after full implementation of ITF. We find that monetary policy shocks have varying impacts on these groups of prices. More sectors respond by lowering their prices following a deposit rate increase, which reflects the dominance of demand factors. These sectors are food and beverages; housing; transportation, communication and financial services; clothing, and others. They also respond to different degrees. Meanwhile, prices in the entertainment, health and education sectors respond by rising. This may be because the supply side effect is dominant in these groups of prices. Another possible explanation is price adjustment costs in these sectors, which are non-traded, are convex (as in Rotemberg, 1982). The firms may already have embarked on a gradual sequence of price increases, from which deflation will take more time following a policy rate increase.

Heterogeneity is also found in the behaviour of prices in response to macroeconomic and sector specific shocks. Boivin, Giannoni and Mihov (2009) show that the source of the volatility of aggregate inflation in the US is different from disaggregated inflation. For them, the volatility apparent in disaggregated inflation, as shown in Bils and Klenow (2004), is mostly related to sector specific shocks. It is not attributed to macroeconomic shocks, particularly a monetary one. Our findings are different. Our

estimation results show that the volatility of inflation mainly comes from the volatility of sector specific shocks rather than macroeconomic ones in both aggregate and disaggregated inflation, and both in core as well as non-core inflation. The heterogeneity is therefore not only in terms of the magnitude and speed of adjustment of the impulse responses, but also in terms of how prices respond to the shocks, and which factors are more dominant in influencing which group of prices.

The policy implication is that the pursuit of price stability calls for careful inspection of specific aspects of prices in addition to the movement of macroeconomic variables. For instance, policy makers should watch and predict the movements of some indicators that are closely associated with some prices that have high weights on the CPI. This provides a way of anticipating the movement of those prices in the future.

Using FAVAR, we can analyse the impulse responses to macroeconomic and sector specific shocks. Different responses are exhibited to these two different shocks. On average, disaggregated prices are more flexible in response to sector specific shocks, as a new equilibrium of prices is reached more rapidly. The magnitudes of impulse responses are also greater on average. Disaggregated prices are more sluggish in response to macroeconomic shocks; although they also react instantaneously, they still take a longer time to reach a new equilibrium. The speed of adjustment to macroeconomic shocks is slower than that of sector specific shocks. These differences show that the source of shocks matters: prices are more insensitive to macroeconomic shocks and more sensitive to sector specific ones. This conclusion is in accord with that of BGM using US data.

We find a negative correlation between the persistence and volatility of inflation, in both core and non-core inflation. This matches the prediction of the Calvo model and might suggest that this model is suitable for capturing the inflation volatility and

persistence in Indonesia. As this negative correlation is stronger in the sector specific component, the Calvo model might be more suitable for explaining the fluctuations in inflation volatility and persistence in facing sector specific shocks.

Macroeconomic shocks imply a shock to macroeconomic variables as a whole. From the monetary policy side, there is a need to evaluate the impact of monetary policy shock on prices. In addition to macroeconomic shocks as a whole, FAVAR also allows us to reveal the impulse response to a specific macroeconomic shock, such as a monetary policy one. Using recursive identification, we impose a shock on the policy rate and evaluate the impulse responses of the prices. We find a persistent price puzzle; on average, prices increase following monetary contraction.

We replace the policy rate with three-month deposit rate and loan rate, as representatives of the market rates, which have more influence on the real sector. We still find the puzzle, but it is no longer persistent. This implies that the deposit and loan rates have more impact on prices than the policy rate. A positive shock on the deposit or loan rate can lower prices, albeit with lags, given the puzzle in the initial period.

In light of the above results and to examine the influence of the change in interest rate on prices, we test whether the deposit or the loan rate has a closer relationship with the policy rate. We estimate the long run relationships between the policy rate and both the deposit and the loan rate and find the relationship between the policy rate and the deposit rate is the stronger. Based on this, we replace the policy rate as the observable variable by the deposit rate.

We find that the price puzzle is present in the full period of estimation. We also separate the sample into two periods based on the full implementation of ITF and find that the puzzle weakens once ITF is adopted, even disappearing if we impose one lag after the

ITF. This suggests that the implementation of ITF is successful in leading prices through movements in the deposit rate. Another explanation is that the indicators during the ITF period have accommodated future inflation.

Given the stronger effect of the deposit rate on prices under ITF, we also examine the impulse responses of various macroeconomic variables during this period. Monetary contraction squeezes the components of GDP. Exports decrease as the exchange rate appreciates and consumption and investment also fall. Imports also decrease significantly as domestic demand falls. As a result, this combination insulates GDP to some extent. Overall, the decrease in aggregate prices is stronger than in output, which may suggest a steep aggregate supply curve, with more prices flexible.

These findings also raise some interesting questions for future exploration. Which class of model can best mimic price behaviour in Indonesia: a time dependent or a state dependent model? Even though there is an indication that time dependent models such as the Calvo one are not inconsistent with price behaviour in Indonesia, it would be worth confirming this. As regards the price puzzle, it would be interesting to explore whether demand or supply factors are more influential in price behaviour. It would also be worthwhile for future work to explore further the sticky and flexible prices of these disaggregated inflation data to obtain information on the state of the economy, as demonstrated by Millard and O'Grady (2012).

Appendix 5.1. Data Description

The data consist of 663 disaggregated elements in Indonesia Consumer Price Index and 92 indicators of the Indonesia and world economies.

No	Name	Sample	Transformation	Description	Unit	Source
1-663	CPI1-CPI663	2002:3 - 2011:12	log difference	Disaggregated Consumer Price Index	Index	Bank Indonesia
664	CPI	2002:3 - 2011:12	log difference	Consumer Price Index	Index	Bank Indonesia
665	Core	2002:3 - 2011:12	log difference	Core Index	Index	Bank Indonesia
666	Vfood	2002:3 - 2011:12	log difference	Volatile Food Index	Index	Bank Indonesia
667	Adm	2002:3 - 2011:12	log difference	Administered Price Index	Index	Bank Indonesia
668	alcom	2002:3 - 2011:12	log difference	All World Primary Commodities Price	Index	IMF
669	nfuel	2002:3 - 2011:12	log difference	World Non-Fuel Primary Commodities Price	Index	IMF
670	food	2002:3 - 2011:12	log difference	World Food Price	Index	IMF
671	energy	2002:3 - 2011:12	log difference	World Energy Price	Index	IMF
672	ip_bi	2002:3 - 2011:12	log difference	Industrial Production Index_BI	index	Bank Indonesia
673	ip_food	2002:3 - 2011:12	log difference	IPI_Food_ Beverages Tobacco	index	Bank Indonesia
674	ip_tex	2002:3 - 2011:12	log difference	IPI_Textiles	index	Bank Indonesia
675	ip_wood	2002:3 - 2011:12	log difference	IPI_Wood&Prod Woods	index	Bank Indonesia
676	ip_pap	2002:3 - 2011:12	log difference	IPI_Paper& Paper Product	index	Bank Indonesia
677	ip_chem	2002:3 - 2011:12	log difference	IPI_Chemicals& Chemical Product	index	Bank Indonesia
678	ip_nmet	2002:3 - 2011:12	log difference	IPI_NonMetallic Mineral Product	index	Bank Indonesia
679	ip_met	2002:3 - 2011:12	log difference	IPI_Basic Metals	index	Bank Indonesia
No	Name	Sample	Transformation	Description	Unit	Source
680	ip_mach	2002:3 - 2011:12	log difference	IPI_Machinery& Equipment	index	Bank Indonesia

No	Name	Sample	Transformation	Description	Unit	Source
681	ip_othi	2002:3 - 2011:12	log difference	IPI_Other Industry	index	Bank Indonesia
682	ut_bi	2002:3 - 2011:12	No transformation	Capacity Utilization_BI	Percent	Bank Indonesia
683	ut_food	2002:3 - 2011:12	No transformation	Capacity Utilization FoodBeverage Tobacco	Percent	Bank Indonesia
684	ut_tex	2002:3 - 2011:12	No transformation	Capacity Utilization_Textiles	Percent	Bank Indonesia
685	ut_wood	2002:3 - 2011:12	No transformation	Capacity Utilization_Wood& Woods Product	Percent	Bank Indonesia
686	ut_pap	2002:3 - 2011:12	No transformation	Capacity Utilization_Paper& Paper Product	Percent	Bank Indonesia
687	ut_chem	2002:3 - 2011:12	No transformation	Capacity Utilization_Chemicals&ChemicalProd	Percent	Bank Indonesia
688	ut_nmet	2002:3 - 2011:12	No transformation	Capacity Utilization_Non MetallicMineralProd	Percent	Bank Indonesia
689	ut_met	2002:3 - 2011:12	No transformation	Capacity Utilization_Basic Metals	Percent	Bank Indonesia
690	ut_mach	2002:3 - 2011:12	No transformation	Capacity Utilization_Machinery&Equip	Percent	Bank Indonesia
691	ut_othi	2002:3 - 2011:12	No transformation	Capacity Utilization_Other Industry	Percent	Bank Indonesia
692	ipi_bps	2002:3 - 2011:12	log difference	Industrial Production Index_BPS	index	Bank Indonesia
693	pr_car	2002:3 - 2011:12	log difference	Car production of Gaikindo	unit	Bank Indonesia
694	s_car	2002:3 - 2011:12	log difference	Sales_Car	unit	Bank Indonesia
695	s_mot	2002:3 - 2011:12	log difference	Sales_Motor	unit	Bank Indonesia
696	cr_ind	2002:3 - 2011:12	log difference	Industry_credit	Billion Rp	Bank Indonesia
697	cem_sales	2002:3 - 2011:12	log difference	Cement_sales	Thousand Ton	Bank Indonesia
698	cr_cntr	2002:3 - 2011:12	log difference	construction_credit	Billion Rp	Bank Indonesia
699	cr_prop	2002:3 - 2011:12	log difference	property_credit	Billion Rp	Bank Indonesia

No	Name	Sample	Transformation	Description	Unit	Source
700	spe_tot	2002:3 - 2011:12	log difference	Retail Sales Index_BI	index	Bank Indonesia
701	spe_food	2002:3 - 2011:12	log difference	Retail Sales Index_Food	index	Bank Indonesia
702	spe_tex	2002:3 - 2011:12	log difference	Retail Sales Index_Apparels	index	Bank Indonesia
703	spe_rt	2002:3 - 2011:12	log difference	Retail Sales Index_Household Appliances	index	Bank Indonesia
704	spe_chem	2002:3 - 2011:12	log difference	Retail Sales Index_Chemicals	index	Bank Indonesia
705	spe_const	2002:3 - 2011:12	log difference	Retail Sales Index_Construction Materials	index	Bank Indonesia
706	spe_fuel	2002:3 - 2011:12	log difference	Retail Sales Index_Gasoline	index	Bank Indonesia
707	spe_atk	2002:3 - 2011:12	log difference	Retail Sales Index_Writing Equipment	index	Bank Indonesia
708	spe_parts	2002:3 - 2011:12	log difference	Retail Sales Index_Motor Vehicles & Spare Part	index	Bank Indonesia
709	spe_craft	2002:3 - 2011:12	log difference	Retail Sales Index_Handycrafts, Arts & Toys	index	Bank Indonesia
710	car_load	2002:3 - 2011:12	log difference	Cargo_Load	Ton	Bank Indonesia
711	car_unl	2002:3 - 2011:12	log difference	Cargo_Unload	Ton	Bank Indonesia
712	cr_cons	2002:3 - 2011:12	log difference	consumption credit	Billion Rp	Bank Indonesia
713	m_cons	2002:3 - 2011:12	log difference	imports of consumption goods	Thousand Ton	Bank Indonesia
714	mtr_sale	2002:3 - 2011:12	log difference	motorcycle sales	unit	Bank Indonesia
715	car_sale	2002:3 - 2011:12	log difference	car sales	unit	Bank Indonesia
716	cci_bi	2002:3 - 2011:12	log difference	consumer confidence index (BI)	index	Bank Indonesia
717	cem_cons	2002:3 - 2011:12	log difference	cement consumption	Thousand Ton	Bank Indonesia
718	cr_inv	2002:3 - 2011:12	log difference	investment credit	Billion Rp	Bank Indonesia
719	ipi_mach	2002:3 - 2011:12	log difference	IPI machinery	index	Bank Indonesia

No	Name	Sample	Transformation	Description	Unit	Source
720	ifo_euro	2002:3 - 2011:12	log difference	IFO Biz Climate-Europe	Index	Bank Indonesia
721	m_cap	2002:3 - 2011:12	log difference	imports of capital goods	Thousand Ton	Bank Indonesia
722	m_raw	2002:3 - 2011:12	log difference	imported raw materials	Thousand Ton	Bank Indonesia
723	x_tim	2002:3 - 2011:12	log difference	Export Timber	Thousand Ton	Bank Indonesia
724	x_rub	2002:3 - 2011:12	log difference	Export Rubber	Thousand Ton	Bank Indonesia
725	x_cof	2002:3 - 2011:12	log difference	Export coffee	Thousand Ton	Bank Indonesia
726	x_tea	2002:3 - 2011:12	log difference	Export Tea	Thousand Ton	Bank Indonesia
727	x_pep	2002:3 - 2011:12	log difference	Export Pepper	Thousand Ton	Bank Indonesia
728	x_tob	2002:3 - 2011:12	log difference	Export Tobacco	Thousand Ton	Bank Indonesia
729	x_mnc	2002:3 - 2011:12	log difference	Export Manioc	Thousand Ton	Bank Indonesia
730	x_ani	2002:3 - 2011:12	log difference	Export Animal_Husb_Prod	Thousand Ton	Bank Indonesia
731	x_hid	2002:3 - 2011:12	log difference	Export Hides	Thousand Ton	Bank Indonesia
732	x_otha	2002:3 - 2011:12	log difference	Export Others	Thousand Ton	Bank Indonesia
733	x_cpo	2002:3 - 2011:12	log difference	Export Palm Oils	Thousand Ton	Bank Indonesia
734	cr_agri	2002:3 - 2011:12	log difference	Export Agriculture Credit	Billions Rp	Bank Indonesia
735	x_tin	2002:3 - 2011:12	log difference	Export Tin	Thousand Ton	Bank Indonesia
736	x_cop	2002:3 - 2011:12	log difference	Export Copper	Thousand Ton	Bank Indonesia
737	x_ni	2002:3 - 2011:12	log difference	Export Nickel	Thousand Ton	Bank Indonesia
738	x_al	2002:3 - 2011:12	log difference	Export Aluminum	Thousand Ton	Bank Indonesia
739	x_coa	2002:3 - 2011:12	log difference	Export Coal	Thousand Ton	Bank Indonesia
740	x_othm	2002:3 - 2011:12	log difference	Export Others Mining	Thousand Ton	Bank Indonesia
741	cr_min	2002:3 - 2011:12	log difference	Mining Credit	Billions Rp	Bank Indonesia
742	gdprl	2002:3 - 2011:12	log difference	Real GDP, interpolated	Billions Rp	BPS

No	Name	Sample	Transformation	Description	Unit	Source
743	csgprl	2002:3 - 2011:12	log difference	Real total consumption,	Billions Rp	BPS
744	invrl	2002:3 - 2011:12	log difference	Real total investment, interpolated	Billions Rp	BPS
745	xgsrl	2002:3 - 2011:12	log difference	Real export, interpolated	Billions Rp	BPS
746	mgsrl	2002:3 - 2011:12	log difference	Real import, interpolated	Billions Rp	BPS
747	stock	2002:3 - 2011:12	First difference	Real stock, interpolated	Billions Rp	BPS
748	curr	2002:3 - 2011:12	log difference	Currency in circulation	Billions Rp	IMF
749	brmo	2002:3 - 2011:12	log difference	Broad Money	Billions Rp	IMF
750	mo	2002:3 - 2011:12	log difference	Base Money	Billions Rp	IMF
751	rpusd	2002:3 - 2011:12	log difference	Nominal Exchange Rate	Rp/USD	IMF
752	monr	2002:3 - 2011:12	No trans formation	Call Money Rate	Percent	IMF
753	loanr	2002:3 - 2011:12	No trans formation	Working Capital Loan Rate	Percent	IMF
754	depr	2002:3 - 2011:12	No trans formation	3 Months Deposit Rate	Percent	IMF
755	birate	2002:3 - 2011:12	No trans formation	Bank Indonesia Policy Rate	Percent	IMF

Appendix 5.2. Number of Factors Based on Bai and Ng (2002) Approach

These results are based on Bai and Ng (2002) method and performed with MatLab code created by Schumacher and Breitung (2008). This methodology is suitable for the case of large number of series (N) and observations (T), $N, T \rightarrow \infty$, as in our case. This criterion also allow for both limited time series and cross section dependence and heteroskedasticity. However, Bai and Ng (2002) limit the factors that have contemporaneous relationship with the observed series, and this approach also applies only on balance panel.

Bai and Ng (2002) compare some criteria namely PC1, PC2, PC3, IC1, IC2, and IC3. Based on their experiments, either IC1 or IC2 are the robust criteria close to our case (similar N and T). We choose IC1 as this gives a greater number of factor to capture more similarity of the data movements.

Bai and Ng (2002) criteria for full period 2002:3-2011:12

All Series		Max factors allowed								
		2	3	4	5	6	7	8	9	10
	PC1	1	1	1	1	1	1	1	1	1
	PC2	1	1	1	1	1	1	1	1	1
	PC3	1	1	1	1	1	1	1	1	2
	IC1	1	1	1	1	1	1	1	1	1
	IC2	1	1	1	1	1	1	1	1	1
	IC3	1	1	1	1	1	1	1	1	1
CPI series		Max factors allowed								
		2	3	4	5	6	7	8	9	10
	PC1	1	1	1	1	1	1	1	2	2
	PC2	1	1	1	1	1	1	1	1	2
	PC3	1	1	1	1	1	2	2	2	2
	IC1	1	1	1	1	1	1	1	1	1
	IC2	1	1	1	1	1	1	1	1	1
	IC3	1	1	1	1	1	1	1	1	1

Indicators series	Max factors allowed								
	2	3	4	5	6	7	8	9	10
PC1	2	3	4	5	5	5	6	6	6
PC2	1	2	3	3	4	4	5	5	5
PC3	2	3	4	5	6	7	8	9	10
IC1	2	3	4	4	4	4	4	4	4
IC2	1	1	1	1	1	1	1	1	1
IC3	2	3	4	5	6	7	8	9	10

Bai and Ng (2002) criteria for period pre IT 2002:3-2005:6

All Series	Max factors allowed								
	2	3	4	5	6	7	8	9	10
PC1	1	1	1	1	1	1	1	1	1
PC2	1	1	1	1	1	1	1	1	1
PC3	1	1	1	1	1	1	1	1	1
IC1	1	1	1	1	1	1	1	1	1
IC2	1	1	1	1	1	1	1	1	1
IC3	1	1	1	1	1	1	1	1	1
CPI series	Max factors allowed								
	2	3	4	5	6	7	8	9	10
PC1	1	1	1	1	1	1	1	1	2
PC2	1	1	1	1	1	1	1	1	2
PC3	1	1	1	1	1	1	1	2	2
IC1	1	1	1	1	1	1	1	1	1
IC2	1	1	1	1	1	1	1	1	1
IC3	1	1	1	1	1	1	1	1	1
Indicators series	Max factors allowed								
	2	3	4	5	6	7	8	9	10
PC1	1	2	3	3	4	4	4	5	6
PC2	1	1	2	3	3	3	4	4	4
PC3	2	3	4	4	5	6	7	7	9
IC1	1	1	1	1	1	1	1	1	1
IC2	1	1	1	1	1	1	1	1	1
IC3	2	3	4	4	4	4	4	4	4

Bai and Ng (2002) criteria for period post IT 2005:7-2011:12

All Series		Max factors allowed								
		2	3	4	5	6	7	8	9	10
	PC1	1	1	1	1	1	1	1	1	1
	PC2	1	1	1	1	1	1	1	1	1
	PC3	1	1	1	1	1	1	1	2	2
	IC1	1	1	1	1	1	1	1	1	1
	IC2	1	1	1	1	1	1	1	1	1
	IC3	1	1	1	1	1	1	1	1	1
CPI series		Max factors allowed								
		2	3	4	5	6	7	8	9	10
	PC1	1	1	1	1	1	1	1	2	2
	PC2	1	1	1	1	1	1	1	1	2
	PC3	1	1	1	1	1	2	2	2	2
	IC1	1	1	1	1	1	1	1	1	1
	IC2	1	1	1	1	1	1	1	1	1
	IC3	1	1	1	1	1	1	1	1	1
Indicators		Max factors allowed								
series		2	3	4	5	6	7	8	9	10
	PC1	2	3	4	4	5	6	6	6	6
	PC2	1	2	2	3	4	4	4	6	6
	PC3	2	3	4	5	6	7	8	9	10
	IC1	2	2	4	4	4	4	4	4	4
	IC2	1	1	1	1	1	1	1	1	1
	IC3	2	3	4	5	6	7	8	9	10

Appendix 5.3. Lags Criteria Results

Lag criteria for full period 2002:3-2011:12

VAR Lag Order Selection Criteria

Endogenous variables: F1A F2A F3A F4A F5A Y_A

Exogenous variables: C

Date: 05/29/12 Time: 09:08

Sample: 2000M01 2011M12

Included observations: 106

Lag	LogL	LR	FPE	AIC	SC	HQ
0	69.72229	NA	1.21E-08	-1.202307	-1.051547	-1.141203
1	391.1003	600.3098	5.56E-11	-6.586798	-5.531473	-6.159069
2	483.6822	162.4551	1.92E-11	-7.654381	-5.694492*	-6.860028*
3	520.787	60.90778	1.91E-11	-7.675226	-4.810772	-6.514247
4	560.324	60.42451*	1.85e-11*	-7.741962*	-3.972944	-6.214359
5	585.4612	35.57155	2.39E-11	-7.537004	-2.863422	-5.642776
6	615.0748	38.55351	2.91E-11	-7.416505	-1.838359	-5.155652
7	646.9821	37.92761	3.52E-11	-7.339285	-0.856575	-4.711808
8	681.9248	37.57989	4.21E-11	-7.319336	0.067938	-4.325234

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Lag criteria for period pre IT 2002:3-2005:6

VAR Lag Order Selection Criteria

Endogenous variables: F1_PREITF F2_PREITF Y_PREITF

Exogenous variables: C

Date: 05/30/12 Time: 15:39

Sample: 2002M03 2005M06

Included observations: 37

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-37.55651	NA	1.80E-03	2.192244	2.322859	2.238292
1	49.4687	155.2342	2.66E-05	-2.025335	-1.502875*	-1.841144
2	65.17112	25.46338*	1.87e-05*	-2.3876*	-1.473323	-2.065293*
3	68.63852	5.060528	2.59E-05	-2.0886	-0.782419	-1.62809

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Lag criteria for period post IT 2005:7-2011:12

Endogenous variables: F1_POSTITF F2_POSTITF F3_POSTITF F4_POSTITF F5_POSTITF
Y_POSTITF

Exogenous variables: C

Date: 05/30/12 Time: 16:19

Sample: 2005M07 2011M12

Included observations: 69

Lag	LogL	LR	FPE	AIC	SC	HQ
0	69.71394	NA	6.35E-09	-1.846781	-1.652511	-1.769707
1	337.6019	481.4218	7.69E-12	-8.568171	-7.20828*	-8.028657
2	402.7241	105.7057*	3.4e-12*	-9.412294	-6.886782	-8.410339*
3	434.1534	45.54967	4.10E-12	-9.279809	-5.588677	-7.815414
4	472.5877	49.01763	4.31E-12	-9.350368	-4.493615	-7.423532
5	508.5289	39.58743	5.31E-12	-9.348664	-3.32629	-6.959387
6	555.3735	43.45007	5.43E-12	-9.663*	-2.475006	-6.811283

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

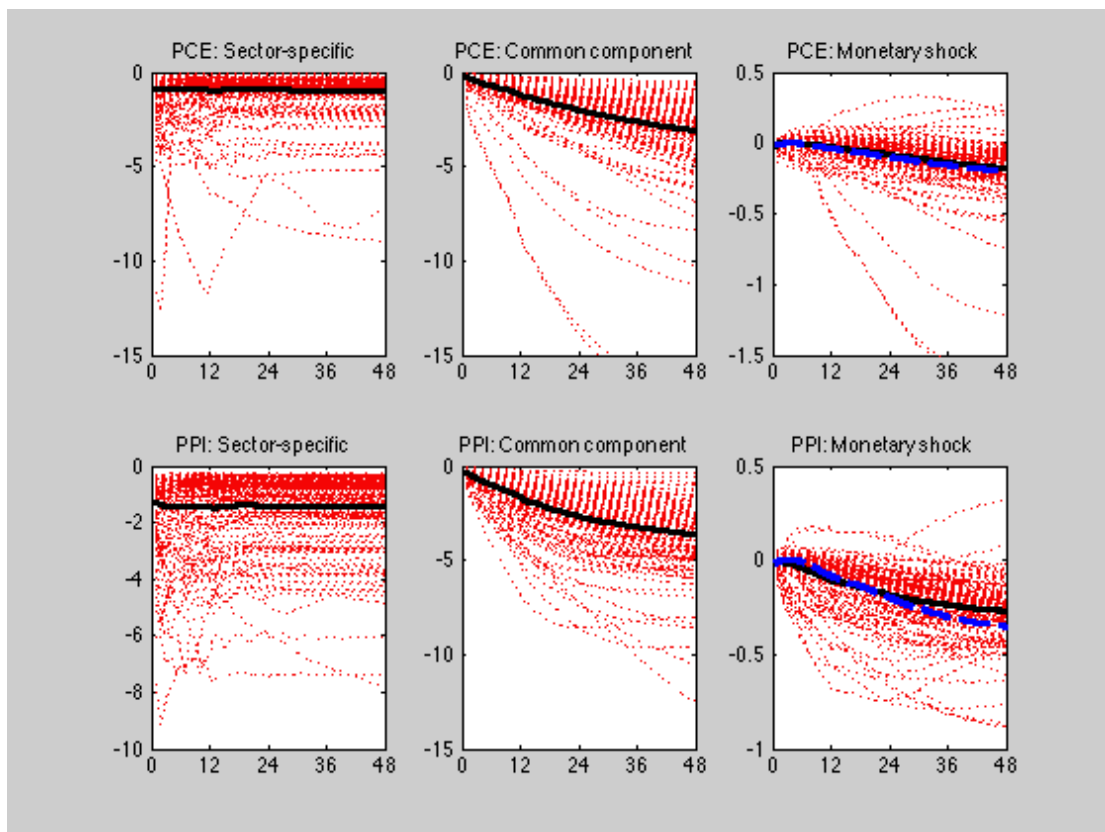
AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Appendix 5.4. Boivin, Giannoni, Mihov (2009) Impulse Responses

These figures are the impulse responses of Personal Consumption Expenditures (PCE) and Producer Price Index (PPI) of US data to sector specific shocks, common component shocks, and monetary policy shock. These figures provide comparison between the impulse responses of prices of US data and Indonesia data.



Appendix 5.5. Unit Root Test for the Interest Rate

Augmented Dickey-Fuller (ADF) Unit Root Test. Ho: the series has unit root

	BI Rate		Deposit Rate		Loan Rate	
Full Period						
- with intercept	-3.19	**	-3.31	**	-2.20	
- with intercept & trend	-3.32	*	-3.47	*	-3.16	*
- none	-1.89	*	-1.55		-1.47	
Pre ITF						
- with intercept	-3.74	***	-1.85		-1.36	
- with intercept & trend	0.76		-1.20		-0.52	
- none	-2.76	***	-1.10		-1.93	*
Post ITF						
- with intercept	-1.93		-2.67	*	-1.66	
- with intercept & trend	-4.18	*	-5.68	***	-3.70	**
- none	-0.83		-0.55		-0.50	

***, **, * significance at 1%, 5%, 10%

Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Unit Root Test. Ho: the series is stationary

	BI Rate		Deposit Rate		Loan Rate	
Full Period						
- with intercept	0.65	**	0.41	*	0.68	**
- with intercept & trend	0.08		0.10		0.11	
Pre ITF						
- with intercept	0.68	**	0.69	**	0.75	***
- with intercept & trend	0.21	**	0.18	**	0.12	*
Post ITF						
- with intercept	0.94	***	0.55	**	0.68	**
- with intercept & trend	0.10		0.06		0.08	

*** significance at 1%

** significance at 5%

* significance at 10%

Appendix 5.6. ECM Model for the Deposit Rate and Loan Rate

	Deposit Rate					
	Full Period		Pre ITF		Post ITF	
d(deposit rate(t-1))	0.717	***	0.720	***	0.688	***
	<i>0.041</i>		<i>0.078</i>		<i>0.045</i>	
d(policy rate)	0.266	***	0.131	***	0.391	***
	<i>0.050</i>		<i>0.035</i>		<i>0.055</i>	
ecm(-1)	-0.043	***	-0.112	***	-0.035	***
	<i>0.013</i>		<i>0.027</i>		<i>0.016</i>	
C	0.404		-1.955	***	3.194	**
	<i>1.146</i>		<i>0.720</i>		<i>1.738</i>	
policy rate(t-1)	0.969	***	1.166	***	0.662	***
	<i>0.128</i>		<i>0.077</i>		<i>0.200</i>	
Adj R ²	0.875		0.847		0.906	
F serial correlation	0.800		0.137		2.330	
	[0.209]		[0.712]		[0.127]	
F functional form	0.800		0.721		13.788	
	[0.371]		[0.396]		[0.000]	
F heteroskedasticity	7.043		0.775		1.900	
	[0.008]		[0.379]		[0.172]	

***, **, * are significance at 1%, 5%, 10% respectively

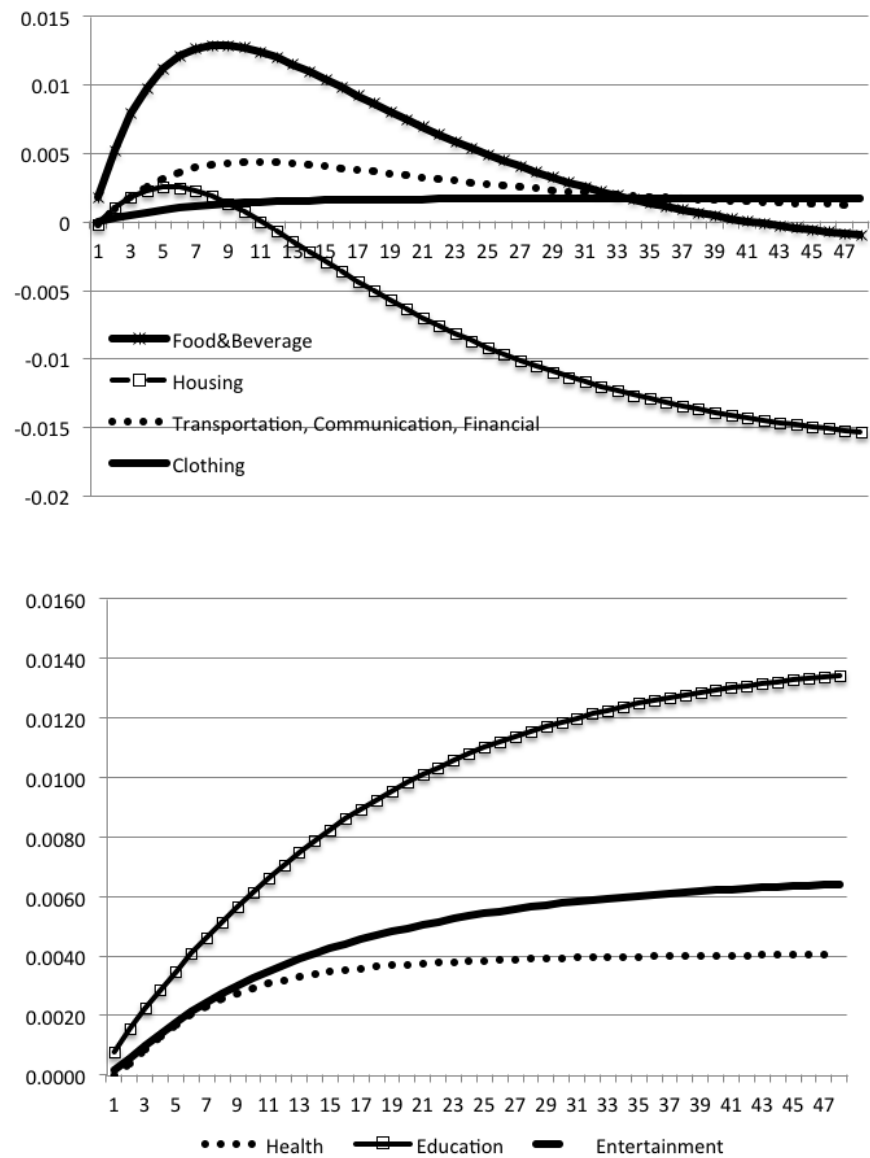
italic are standard error, [] p value

		Loan Rate					
		Full Period		Pre ITF		Post ITF	
d(loan rate(t-1))		0.403	***			0.492	***
		<i>0.071</i>				<i>0.105</i>	
d(policy rate)		0.285	***	0.081	***	0.562	***
		<i>0.051</i>		<i>0.013</i>		<i>0.085</i>	
d(policy rate(-1))						-0.274	***
						0.106	
ecm(-1)		-0.041	***	-0.108	***	-0.038	
		<i>0.017</i>		<i>0.016</i>		<i>0.026</i>	
	c	5.634	***	7.279	***	6.808	**
		<i>1.863</i>		<i>0.579</i>		<i>2.869</i>	
	policy rate(t-1)	0.986	***	0.752	***	0.853	**
		<i>0.204</i>		<i>0.049</i>		<i>0.337</i>	
Adj R ²		0.626		0.526		0.678	
F serial correlation		0.336		2.026		1.156	
		[0.562]		[0.155]		[0.282]	
F functional form		0.624		0.374		0.779	
		[0.429]		[0.541]		[0.378]	
F heteroskedasticity		0.347		1.286		1.378	
		[0.556]		[0.257]		[0.241]	

***, **, * are significance at 1%, 5%, 10% respectively

italic are standard error, [] p value

Appendix 5.7. The Impulse Responses of Groups of Prices to Loan Rate Shocks



Appendix 5.8. MatLab Code (the Main Code)

```
=====
% Main program
%
% By Jean Boivin, Marc Giannoni and Ilian Mihov
% Revised: 9/12/08
%
% Modified by IGP Wira Kusuma
% Revised: 7/5/12
% =====

%%%%%%%%%%%%%% Data and Preliminary Manipulations %%%%%%%%%%%%%%
clear;

load datafinal.mat;
datam=datafinalpostIT;

vnames=vnames4;
vartcodes=tcodes4;

year=2002:1/12:2011.11;
year=year(2:end-1);

indFFR=755;

Tm      = size(datam,1);
stdffr  = std(datam(:,indFFR));
stdX    = std(datam(:,[1:indFFR-1]));

datam = (datam-repmat(mean(datam,1),Tm,1))./repmat(std(datam),Tm,1);

Y      = datam(:,indFFR);
X      = datam(:,1:indFFR-1);
Xfactor=X;

vnames= [vnames(1:indFFR-1,:)];
vartcodes= [vartcodes(1:indFFR-1,:)];

index=[1:754]';

N = size(X,2);
M = size(Y,2);
K   = 1;
lags  = 2;
nrep1 = 1;
nrep2 = 10;
nsteps = input('Length of impulse responses? (Choose 120, then rerun the
program and choose 48) ');

% Calls the function irfbootfac, which does most of the computations

shock  = [zeros(1,K+M-1) .25/stdffr]';

[Fr0,FYresp,Xresp,Xresp_rest,r2com,varcom,
rho,rhorest,Sigcomrest,Sigeirest,imparx,imparc,impari,idio,impxbs, fy,
```

```

cf, ex] = ...
    irfbootfac(Y, lags, X, 0, stdX, Xfactor, index, K, shock, nsteps-
1, nrep1, nrep2);

save Fr0 Fr0 ;

FYresp = permute(FYresp, [2,1,3]);
Xresp = permute(Xresp, [2,1,3]);

resp = Xresp;
resp_rest=Xresp_rest;

n = size(resp,1);

type=2;
for i = 1:n
    if vartcodes(index(i)) == 4
        resp(i,:,:) = stdX(index(i))*resp(i,:,:);
        resp(i,:,:) = exp(resp(i,:,:))-ones(1,nsteps,3);
        resp_rest(i,:,:) = stdX(index(i))*resp_rest(i,:,:);
        resp_rest(i,:,:) = exp(resp_rest(i,:,:))-ones(1,nsteps,3);
    elseif vartcodes(index(i)) == 5
        resp(i,:,:) = stdX(index(i))*resp(i,:,:);
        resp_rest(i,:,:) = stdX(index(i))*resp_rest(i,:,:);
        if type==2
            resp(i,:,:) = (cumsum(resp(i,:,:),2));
            resp_rest(i,:,:) = (cumsum(resp_rest(i,:,:),2));
        elseif type==3
            resp(i,:,:) = exp(cumsum(resp(i,:,:),2))-ones(1,nsteps,3);
            resp_rest(i,:,:) = exp(cumsum(resp_rest(i,:,:),2))-
ones(1,nsteps,3);
        end
    end
end

resp(1:681,:,:) = 100*resp(1:681,:,:);
resp(692:746,:,:) = 100*resp(692:746,:,:);
resp(748:751,:,:) = 100*resp(748:751,:,:);

resp_rest(1:681,:,:) = 100*resp_rest(1:681,:,:);
resp_rest(692:746,:,:) = 100*resp_rest(692:746,:,:);
resp_rest(748:751,:,:) = 100*resp_rest(748:751,:,:);

resp1 = resp(:,:,1)';
resp2 = resp(:,:,2)';
resp3 = resp(:,:,3)';

FFRresp = FYresp(2,:,:) * stdffr;

Sigci = sqrt((stdX(index).^2)' .* (1-r2com));

figure

for i = 1:n
    if vartcodes(index(i)) == 4
        impari(i,:) = stdX(index(i))*impari(i,:);
        impari(i,:) = exp(impari(i,:))-ones(1,nsteps);
    end
end

```



```

elseif vartcodes(index(i)) == 5
    impari(i,:)=stdX(index(i))*impari(i,:);
    if type==2
        impari(i,:)=(cumsum(impari(i,:),2));
    elseif type==3
        impari(i,:)=exp(cumsum(impari(i,:),2))-ones(1,nsteps);
    end
end
end
end

subplot(131); plot(100*impari(1:663,:), 'r:');
title('All Prices: Sector-specific')
hold on
    plot(1:nsteps,mean(100*impari(1:663,:)), 'k', 'LineWidth', 2.0)
hold off
axis([0 48 -15 0]); grid on;
set(gca, 'XTick', [0 12 24 36 48])

subplot(132); plot(100*impari(1:405,:), 'r:');
title('Core: Sector-specific')
hold on
    plot(1:nsteps,mean(100*impari(1:405,:)), 'k', 'LineWidth', 2.0)
hold off
axis([0 48 -15 0]); grid on;
set(gca, 'XTick', [0 12 24 36 48])

subplot(133); plot(100*impari(406:603,:), 'r:');
title('NonCore: Sector-specific')
hold on
    plot(1:nsteps,mean(100*impari(406:603,:)), 'k', 'LineWidth', 2.0)
hold off
axis([0 48 -15 0]); grid on;
set(gca, 'XTick', [0 12 24 36 48])

print fig01.eps -depsc2

figure
for i = 1:n
    if vartcodes(index(i)) == 4
        imparc(i,:)=stdX(index(i))*imparc(i,:);
        imparc(i,:)=exp(imparc(i,:))-ones(1,nsteps);
    elseif vartcodes(index(i)) == 5
        imparc(i,:)=stdX(index(i))*imparc(i,:);
        if type==2
            imparc(i,:)=(cumsum(imparc(i,:),2));
        elseif type==3
            imparc(i,:)=exp(cumsum(imparc(i,:),2))-ones(1,nsteps);
        end
    end
end
end

subplot(131); plot(100*imparc(1:663,:), 'r:');
title('All Prices: Common component')
hold on
    plot(1:nsteps,mean(100*imparc(1:663,:)), 'k', 'LineWidth', 2.0)
hold off
axis([0 48 -15 0]); grid on;
set(gca, 'XTick', [0 12 24 36 48])

```

```

subplot(132); plot(100*imparc(1:405,:), 'r:')
title('Core: Common component')
hold on
    plot(1:nsteps, mean(100*imparc(1:405,:)), 'k', 'LineWidth', 2.0)
hold off
axis([0 48 -15 0]); grid on;
set(gca, 'XTick', [0 12 24 36 48])

subplot(133); plot(100*imparc(406:663,:), 'r:')
title('NonCore: Common component')
hold on
    plot(1:nsteps, mean(100*imparc(406:663,:)), 'k', 'LineWidth', 2.0)
hold off
axis([0 48 -15 0]); grid on;
set(gca, 'XTick', [0 12 24 36 48])

print fig02.eps -depsc2

figure

for i = 1:n
    if vartcodes(index(i)) == 4
        imparx(i,:) = stdX(index(i)) * imparx(i,:);
        imparx(i,:) = exp(imparx(i,:)) - ones(1, nsteps);
    elseif vartcodes(index(i)) == 5
        imparx(i,:) = stdX(index(i)) * imparx(i,:);
        if type == 2
            imparx(i,:) = (cumsum(imparx(i,:), 2));
        elseif type == 3
            imparx(i,:) = exp(cumsum(imparx(i,:), 2)) - ones(1, nsteps);
        end
    end
end

subplot(131); plot(100*imparx(1:663,:), 'r:')
title('All Prices')
hold on
    plot(1:nsteps, mean(100*imparx(1:663,:)), 'k', 'LineWidth', 2.0)
hold off
axis([0 48 -15 0]); grid on;
set(gca, 'XTick', [0 12 24 36 48])

subplot(132); plot(100*imparx(1:405,:), 'r:')
title('Core')
hold on
    plot(1:nsteps, mean(100*imparx(1:405,:)), 'k', 'LineWidth', 2.0)
hold off
axis([0 48 -15 0]); grid on;
set(gca, 'XTick', [0 12 24 36 48])

subplot(133); plot(100*imparx(406:663,:), 'r:')
title('NonCore')
hold on
    plot(1:nsteps, mean(100*imparx(406:663,:)), 'k', 'LineWidth', 2.0)
hold off
axis([0 48 -15 0]); grid on;
set(gca, 'XTick', [0 12 24 36 48])

```

```

print fig03.eps -depsc2

figure

pceirf = resp(1:663, :, 1);
pceirfa = resp(1:663, :, :);
subplot(131); plot(pceirf, 'r:');
title('All Price: Monetary shock')
hold on
    plot(1:nsteps, squeeze(mean(pceirfa(:, :, 1))), 'b', 'LineWidth', 2)
hold off
axis([0 48 -5 5]); grid on;
set(gca, 'XTick', [0 12 24 36 48])

ppiirf1 = resp(1:405, :, 1);
ppiirfa1 = resp(1:405, :, :);
subplot(132); plot(ppiirf1, 'r:');
title('Core: Monetary shock')
hold on
    plot(1:nsteps, squeeze(mean(ppiirfa1(:, :, 1))), 'b', 'LineWidth', 2)
hold off
axis([0 48 -5 5]); grid on;
set(gca, 'XTick', [0 12 24 36 48])

ppiirf2 = resp(406:663, :, 1);
ppiirfa2 = resp(406:663, :, :);
subplot(133); plot(ppiirf2, 'r:');
title('NonCore: Monetary shock')
hold on
    plot(1:nsteps, squeeze(mean(ppiirfa2(:, :, 1))), 'b', 'LineWidth', 2)
hold off
axis([0 48 -5 5]); grid on;
set(gca, 'XTick', [0 12 24 36 48])

print fig04.eps -depsc2

figure

ip = resp(672:672, :, :);
subplot(331); plot(1:nsteps, squeeze(ip(:, :, 1)),
    'k', 1:nsteps, squeeze(ip(:, :, 2)), 'r:', 1:nsteps, squeeze(ip(:, :, 3)), 'r:',
    'LineWidth', 2)
title('Prod.Index: Monetary shock')
axis tight; grid on;
set(gca, 'XTick', [0 12 24 36 48])

usdrp = resp(751:751, :, :);
subplot(332); plot(1:nsteps, squeeze(usdrp(:, :, 1)),
    'k', 1:nsteps, squeeze(usdrp(:, :, 2)), 'r:', 1:nsteps, squeeze(usdrp(:, :, 3)),
    'r:', 'LineWidth', 2)
title('Exchange Rate: Monetary shock')
axis tight; grid on;
set(gca, 'XTick', [0 12 24 36 48])

m0 = resp(664:664, :, :);
subplot(333); plot(1:nsteps, squeeze(m0(:, :, 1)),
    'k', 1:nsteps, squeeze(m0(:, :, 2)), 'r:', 1:nsteps, squeeze(m0(:, :, 3)), 'r:',
    'LineWidth', 2)

```

```

title('CPI: Monetary shock')
axis tight; grid on;
set(gca,'XTick',[0 12 24 36 48])

m2 = resp(749:749,:,:);
subplot(334); plot(1:nsteps,squeeze(m2(:,:,1)),
'k',1:nsteps,squeeze(m2(:,:,2)), 'r:',1:nsteps,squeeze(m2(:,:,3)), 'r:',
'LineWidth', 2)
title('Broad Money: Monetary shock')
axis tight; grid on;
set(gca,'XTick',[0 12 24 36 48])

gdp = resp(742:742,:,:);
subplot(335); plot(1:nsteps,squeeze(gdp(:,:,1)),
'k',1:nsteps,squeeze(gdp(:,:,2)), 'r:',1:nsteps,squeeze(gdp(:,:,3)),
'r:', 'LineWidth', 2)
title('GDP: Monetary shock')
axis tight; grid on;
set(gca,'XTick',[0 12 24 36 48])

cspg = resp(743:743,:,:);
subplot(336); plot(1:nsteps,squeeze(cspg(:,:,1)),
'k',1:nsteps,squeeze(cspg(:,:,2)), 'r:',1:nsteps,squeeze(cspg(:,:,3)),
'r:', 'LineWidth', 2)
title('Consumption: Monetary shock')
axis tight; grid on;
set(gca,'XTick',[0 12 24 36 48])

inpg = resp(744:744,:,:);
subplot(337); plot(1:nsteps,squeeze(inpg(:,:,1)),
'k',1:nsteps,squeeze(inpg(:,:,2)), 'r:',1:nsteps,squeeze(inpg(:,:,3)),
'r:', 'LineWidth', 2)
title('Investment: Monetary shock')
axis tight; grid on;
set(gca,'XTick',[0 12 24 36 48])

xgsrl = resp(745:745,:,:);
subplot(338); plot(1:nsteps,squeeze(xgsrl(:,:,1)),
'k',1:nsteps,squeeze(xgsrl(:,:,2)), 'r:',1:nsteps,squeeze(xgsrl(:,:,3)),
'r:', 'LineWidth', 2)
title('Export: Monetary shock')
axis tight; grid on;
set(gca,'XTick',[0 12 24 36 48])

mgsrl = resp(746:746,:,:);
subplot(339); plot(1:nsteps,squeeze(mgsrl(:,:,1)),
'k',1:nsteps,squeeze(mgsrl(:,:,2)), 'r:',1:nsteps,squeeze(mgsrl(:,:,3)),
'r:', 'LineWidth', 2)
title('Import: Monetary shock')
axis tight; grid on;
set(gca,'XTick',[0 12 24 36 48])

print fig05.eps -depsc2

```

Chapter 6

Concluding Remarks

6.1. Conclusions

Most developed countries experienced changes in inflation dynamics after the 1980s¹³. These include lower exchange rate pass through, a flattening Phillips curve, reduced sensitivity to shocks such as those in oil and other commodity prices, and lower inflation persistence. This must at least be partly, perhaps mainly, due to the role of monetary policies. In view of all this, what are the inflation dynamics in developing Asian countries?

The general conclusions of this thesis are that there have also been some changes to inflation dynamics in these countries after the Asian crisis, which vary across countries and across periods. Monetary policy does matter, but it is not the only factor that influences inflation dynamics in the countries under investigation. Other factors such as the preferences of economic agents and supply factors are relevant. Furthermore, exploring disaggregated data helps us to understand price behaviour better.

In Chapter 2 we examined inflation dynamics from two perspectives; inflation persistence and exchange rate pass through (ERPT). We provide a comparison of these dynamics before and after the Asian financial crisis for Hong Kong, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand. We find that, after the Asian crisis, most countries experienced a decline in the mean level of inflation and inflation persistence. In terms of ERPT, the estimation results are less clear cut. However, it is

¹³ For example, Mishkin (2007) records that this happened in the US and other developed countries, the main cause being improved monetary policy. Benati and Surico (2009) also argue that this can be attributed to good policies, not “good luck”, in particular for the great moderation in the US. Other authors, such as Sims-Zha (2006) and Gali and Gambetti (2009), provide different views on this debate.

interesting to note that among the ITF countries under investigation, Indonesia, Korea and Philippines experience declining ERPT, in particular the ERPT to CPI. The lower inflation persistence and exchange rate pass through in these ITF countries may support the arguments found in Taylor (2000) and Mishkin (2007), that more stable monetary conditions and well anchored inflation lead to a lower ERPT. In particular, the ITF that implemented in these countries may contribute to these changes. In order to confirm this, we examine the role of ITF given the changes in inflation dynamics. The estimation results suggest that not all these ITF countries experience a reduction in inflation persistence and ERPT into CPI after ITF implementation. Inflation persistence fell in Korea and Thailand, but the lowering of ERPT into CPI only happened in Korea. This may be because ITF implementation in these two countries happened earlier, thus generating more credibility. Given this result, we cannot infer that ITF always plays a major role in inflation dynamics in Asian countries.

Mishkin (2007) argues that a stable monetary policy, with inflation expectations steadily anchored and supported by an independent monetary policy framework, can reduce the importance of shocks that threaten the stability of inflation dynamics. Chapter 3 examines the Asian evidence for this. As world commodity price shocks are significant for developing economies, we also examine the impact of these shocks, particularly world oil price and food price shocks, on domestic inflation. Chapter 3 quantifies the impact in terms of the first and the second pass through in the 2000s. For the first pass through, the conclusion is that it is significant for both world oil and food prices. On average, the first world oil price pass through is higher and more significant than the world food price pass through. However, if we examine individual countries, results vary. In countries that still impose fuel subsidies or price ceilings, the first pass through is smaller. For food prices,

there is an indication that the first pass through of world prices is closely related to consumption in the country. The greater the food consumption patterns in the country, the higher its pass through tends to be. For the second pass through, we conclude that both food and oil prices have a relatively small second pass through, except for Singapore and Hong Kong. These findings are supported by three estimation approaches that demonstrate a relatively high second pass through in these two countries, with domestic food inflation as the cause. This finding does not support the argument that the second pass through is relatively small in those developed countries that have a lower inflation environment (Taylor, 2000). One should consider in detail what kinds of goods are included as the high degree of dependency of these countries on foreign food supplies might be the cause. In this case, monetary policy might be less effective in dampening world price shocks.

Chapter 4 also examines the impact of world oil and food price shocks from a broader perspective. A DSGE model under a New Keynesian framework is employed to provide an explanation through estimates and simulations of how shocks influence the economy and how monetary authorities respond to these shocks. As we employ the same model structure for all the countries in the analysis, we only examine Indonesia, Korea, Philippines and Thailand. These countries were chosen based on the similarities in their monetary policy framework, that is ITF. The deep parameters reveal the similarities and differences between these countries. For example, in all these four countries non-food prices are more rigid than food prices and wages. Some differences reflect the countries' varying degrees of openness. Korea, the most developed of these four countries, has a higher degree of openness than the other three. The other interesting differences are how the four ITF countries appear to conduct their monetary policy during the period under analysis. We demonstrate that Indonesia places the highest weight on smoothing its interest

rates. All four countries also take into consideration output fluctuations when setting their policy interest rates, with Indonesia also placing the highest weight on this. The countries also consider exchange rates in setting their interest rates; the collapse of their currencies during the Asian financial crisis may still be influencing their monetary policy. Thailand places the highest weight on its exchange rate, possibly reflecting one of its monetary policy objectives: a stable exchange rate. However, in general, the weights of these two variables are smaller than those of inflation. We conclude that all four countries implement ITF consistently, with the coefficient on inflation unambiguously greater than unity, the value required for stability, although they do not adopt ITF strictly, focusing only on inflation and ignoring the fluctuations of other variables.

The simulation results in Chapter 4 also support the findings in Chapter 3, that the first pass through of world oil price shocks is greater than world food price shocks. From the simulations of world oil price shocks, the main conclusion is that both the degree of openness and fuel preference play significant roles, in addition to subsidies. A country that has a low fuel preference combined with a low degree of openness experiences minor increases in its domestic fuel inflation. Indonesia, which has high fuel subsidies, experiences low domestic fuel inflation. One interesting result arises in the world price food shock simulation. The capacity of a country to supply its domestic demand also matters in dampening a world food price shock. We conclude that a country that has a relatively large food sector enjoys less pressure from world food price shocks. Its monetary authority does not need to increase interest rates sharply in response to these shocks. Moreover, the food supply helps to dampen the effect of the shocks, not only in the short term, but also in the longer term. Meanwhile, monetary policy only matters for the short term through the appreciation of the exchange rate.

Chapter 5 explores inflation dynamics by also employing disaggregated data on inflation to complement the analyses in the previous chapters of aggregate data. Here, we only explore a specific country, Indonesia, given the availability of data. The main finding is that the price behaviour in Indonesia exhibits heterogeneity in response to shocks. This is not only in terms of magnitude, but also in the direction and speed of adjustment to the new equilibrium. Disaggregated prices are more flexible in response to sector-specific shocks, but on the other hand they are more sluggish in response to macroeconomic shocks. Although they begin to react instantaneously, they take longer to reach the new equilibrium. These differences show that the source of shocks matters: prices are less responsive to macroeconomic shocks but more sensitive to sector specific ones. Our estimation results also show that the volatility of inflation mainly comes from the volatility of sector specific rather than macroeconomic shocks. This suggests that policy makers should also carefully watch indicators related to a specific price and not only macroeconomic indicators. We also evaluate disaggregated prices in response to monetary policy shocks. We find a price puzzle in the full sample period: average prices increase following a monetary contraction. We split the sample into two periods based on the full implementation of ITF in Indonesia. We find the price puzzle becomes weaker and even disappears if we replace the policy rate with the deposit rate.

6.2. Future Work

At this point we can draw some conclusions and policy implications from the thesis. However, some shortcomings and weaknesses are worth noting for future work.

As regards the estimation of ERPT in Chapter 2, we do not find cointegration for most of the estimations. Hence, we end up with the measurement of the full or cumulative exchange rate pass through instead of the long-run exchange rate pass through. One

possible explanation is that this is simply due to the number of observations. In future work, it may be worth re-estimating the models using a greater number of observations. As the number of observation increases, we can also re-estimate using other approaches.

In Chapter 3 we find an indication that the high first pass through of world food prices is closely related to the food consumption in a country instead of the dependency on imported food. This is an interesting topic for exploration, in particular to measure which factor is more influential in the movement of domestic food inflation. Re-estimates of the second pass through using indicators as instrumental variables for domestic food and fuel inflation for all countries are worth exploring. Using official data on core inflation for the estimation of the second pass through for Hong Kong and Singapore, if available, would also be worth considering.

Chapter 4 employs a more comprehensive model to assess the impact of world commodity price shocks. Even though the model is able to illuminate certain key aspects of the economy, there is still room for improvement. Regarding the underlying simplifications in this model, the role of subsidy is not included, as some developing countries still allocate subsidies for fuel and food consumption. These subsidies need to be modeled explicitly to make the model more realistic. In addition to this, the assumption of LOOP needs to be relaxed to make the model more realistic. Some underlying assumptions of this model may also be too strong. For instance, there is no oil in the production function of firms in food sector. In reality, these firms also need oil as a production factor or in fertilizer. For the estimations, more data may be needed in terms of the number of observations as well as the number of variables. This may help to make the data more informative about some parameters and make the estimation more robust. For the calibrations, some parameters need to be calibrated more precisely to mimic the conditions

in each country; for example, the parameter for domestic food preference that is currently simply set equal to the steady state ratio of the food sector to output. This ratio significantly influences the transmission mechanism of the model. Besides representing household preferences, this ratio should capture more accurately the capacity of a country to meet its domestic demand for food.

The New Keynesian DSGE model studied in Chapter 4 relies, like most studies, on Calvo pricing. As noted in the literature, micro evidence does not always support the Calvo model. It also adopts a common assumption of a frictionless financial market and uses a single interest rate. The relationship between the central bank's policy rate and the commercial deposit rate may be less than perfect and financial frictions may distort agents' behaviour. Enhancing the model with financial friction will be interesting and challenging; see, for example, Curdia and Woodford (2009) and Quadrini (2011). Furthermore, there is the possibility of multiple equilibria of inflation path in this class of model, as noted in Cochrane (2011). These are unsettled issues that question the confidence we have in the New Keynesian DSGE model, though this model is still a valuable approach that has not been superseded by any alternative approach.

In Chapter 5, as we use disaggregated price data, we reveal many findings on price behaviour in Indonesia. These findings also raise some interesting questions for future exploration. For example, which class of model can best mimic the price behaviour in Indonesia: a time dependent or a state dependent model? This chapter shows that time dependent models such as the Calvo one are consistent with price behaviour in Indonesia. However, it is worth confirming this by using these two competing classes of model to mimic disaggregated data on prices. As regards the price puzzle, it would be interesting to explore whether demand or supply factors are more influential on price behaviour. This

question applies for various groups of prices as well as various sample periods, before and after the implementation of ITF in Indonesia. It would also be worthwhile exploring further the sticky and flexible prices of these disaggregated inflation data to obtain information on the state of the economy, as demonstrated by Millard and O'Grady (2012).

Overall, this thesis has explored the inflation dynamics of various countries in Asia. It addresses many relevant research questions, employs various methodologies, and raises interesting findings. It offers the first detailed analytical exploration of inflation dynamics in Asian ITF countries in general, and Indonesia in particular.

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